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TRANSACTIONS
OF THE
NEW ZEALAND INSTITUTE,
1909.

Art. I.—*Oceanic Comparatives.*

By Rev. C. E. Fox.

Communicated by A. Hamilton.

[*Read before the Wellington Philosophical Society, 5th May, 1909.*]

Probably most students of Oceanic languages begin by merely comparing words of similar form and meaning in different languages. Later on, the testimony of words to the beliefs of the people, to their common origin, to the position and character of their home before they became scattered, becomes of great interest. But meanwhile certain principles of comparison emerge from the number of comparisons made, and gradually the comparisons become in consequence sounder. Some comparisons made at first without hesitation are seen to be wrong ones, while many comparisons formerly unthought-of can now be safely made. The following paper describes briefly a few principles of comparison in dealing with Oceanic words. They are principles which seem to be true when tested, but they were obtained by collecting a great many examples of comparatives, and then considering these examples to see if they had anything in common. They appeared to conform to certain rules. These rules were then tested by applying them to many fresh comparatives, with excellent results. In the hope that they may be of service to others, or, at least, may be suggestive, it seemed worth while to write them down.

One side of the subject, however, is not discussed—the question of phonetic changes; it deserves separate treatment, and is too large to be discussed here. But the principle may be at once laid down that no comparison should be made of words whose forms are different unless the difference can be explained according to well-known phonetic laws. One might suppose this caution hardly needed, but it is, in fact, generally ignored. One need only quote a sentence from "Maori and Polynesian": "The Aryan *ra* (to rest, to be delighted, to love) . . . . is not far off in origin from the root *la* (to yearn for or desire), which appears in Sanskrit *lash* (to desire). . . . It seems much the same as the Maori *reka* (pleasant), and, in the other sense of 'calm,' as the Maori *whakaruru* (sheltered from the wind)." Such comparisons may easily be a source of confusion.

Another principle to be insisted on is that all the letters of a word must be taken into consideration. If the Mota *vula* (moon) is compared with the Malay *bulan*, the *n* must be accounted for; if *namu* (mosquito) is compared with *namok*, the *k* must be accounted for. In these two cases the *n* and *k* suffixes, common in Malay nouns, are of great interest to the philologist. It is common to ignore single letters, especially at the end of a word. Much of great interest and value is thus passed by.

It is perhaps best to set aside onomatopoeic words, interesting as they are. The author of "Maori and Polynesian" compares the Maori *mumu* (to hum) with the Latin *murmurare* (to murmur), while "*koko* (the tui) may be set beside the Sanskrit *kakh* (to laugh), English 'quack' and 'cackle.'"[*] Probably such words appear in all languages. There is a Malay word for "dog," *asu*, and this is found in Melanesia, but not in Polynesia: so it has been supposed that the Maori *au* (to bark) represents the Malay *asu* (a dog) - in fact, that nothing but the bark is left in New Zealand. It is a comparison one is loth to forego when one remembers the classic case of the Cheshire cat; but one must allow that "*au au*" is very like the sound a dog makes everywhere.

It seems reasonable to suppose that the fuller form of a word is the root. We are familiar enough with shortened forms *cab*, from cabriolet; *bus*, from omnibus; *car*, from carriage; *phone*, from telephone. It is, no doubt, a common process in all languages. Now, if we take any word of two or three letters (not a particle) in any Ocean language, it appears to be the case that a fuller form of the word can always be found in some other language. Of course, the fuller form may have been lost everywhere, but no such case has come under the writer's observation. These fuller forms consist of two consonants and two vowels, or, at least, of two syllables. Thus, though *hua* is "moon" in one language of Indonesia, *hula* is found in others; though *niu* is "cocoanut" in many Oceanic languages, *niru* is found in one (Vella Lavella). It also appears to be the case that no root-forms occur of more than two syllables. There are many longer words in the vocabularies, but they are either roots plus a prefix or suffix or they are compound words. Thus, in the Mota word *nonom* (think) the *m* is the common Oceanic verbal suffix; in the Mota *malumlum* (soft), *ma* is the common adjectival prefix, while *lumlum* is the reduplicated root (*lumu*). The Florida *tidalo* (a god) is a compound word, *ti* appearing also in *tinoni* (a living man), whatever the meaning may be of *dalo* the same word, doubtless, as the San Cristoval *ataro* (a god); Mota *tataro* (a prayer) - from the first word with which all prayers or charms began; Tahitian *tarotaro* (a short prayer to the gods). The Florida word appears to be indirect evidence that the primitive religion of the people was ancestor-worship. The Mota *geara* (a fence) is really two words *ge* and *ara*—a form of the latter being commonly used for "fence" in Oceanic languages.

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[*] I cannot refrain from giving instances of the curious reasoning and inaccurate statements in the chapter of this book entitled "The Maori as seen in his Language": "Malay, as the tongue of a Mongoloid people, is assumed to be agglutinative. . . . . But there is nothing agglutinative about [Maori] . . . . Now, the only inflectional languages are either Aryan or Semitic." Therefore Maori is either Aryan or Semitic! So much for the reasoning. Later on he speaks of the "coincidence of Maori *ruma* (an apartment), used all through the Pacific in the sense of house, with the English 'room.'" Now, there is no such Maori word at all, and, though *ruma* does occur in Melanesia, neither the word itself nor any form of it is known to occur in Polynesia.

The following principle seems, then, to hold good: that all Oceanic roots consist of two syllables. The first point to determine about a word is this root. But the full form is often missing, and the next point is to find out how these root-forms are modified. In the first place, the first consonant may be dropped. The Florida *aho* (the sun) is a modified form of *raho* or *laho*. This modification is a common one. Still more common is the dropping of the second consonant, especially in Polynesia. The full form of the Maori *kau* (to swim or wade) is *karu*, the word really meaning "to move the legs and arms."

In many cases both consonants are dropped, as in the Rarotongan *ai* (fire), the root of which is *kapi*; or the Maori *ao* (dawn), from *raho*.

Sometimes the second vowel is dropped, as in the Mota *kor* (dried), from *koro;* but the first vowel remains, and is rarely altered; it is, in fact, the most stable part of the word. On the other hand, the second vowel is liable to frequent change.

The commonest modification of all is the dropping of the second syllable. Thus, the Maori *ra* (sun) is from *raho;* *po* (night) from *pongi;* *pa* (a fence or stockade) from *para*. It frequently happens that when only the first syllable remains this is strengthened by reduplication. Thus Mota *koko* (enclose) is from *koro;* Mota *rara* (scorch), from *raho;* Mota *roro* (deep), from *roto;* Mota *lolo* (inner parts), from *roto;* Mota *roroi* (news), from *rongo;* Maori *rara* (a branch), from *rana;* Fiji *baba* (side of a hill), from *bara*. Such reduplications are very common.

Perhaps there are cases of the dropping of the first syllable of the root; but until they are shown to exist, such comparisons as that of the Mota *qana* (to eat) with the Malay *makan* (to eat) must be viewed with suspicion. *Manga*, which also appears as *maka*, means originally "a cleft or rent," in some languages "a mouth"; in Mota "to keep opening and shutting, as the gills of a fish." This is, no doubt, the Mota representative of the Malay *makan* (to eat), the *n* being the common verbal suffix.

There is yet another fairly common modification of the root by metathesis. Thus, the Florida *labu* (strike) is the Malay *palu;* the Mota *toro* (deep), the Maori *roto;* the Mota *ma vinvin* (thin), from *nihi;* Maori *ngaro* (fly), from *rango;* Maori *raku* (scratch), from *karu;* Aneityum *mulmul* (soft), from *lumu;* Tongan *pelupelu* (bent), from *lupe;* Maori *tumu* (cape), from *mutu*. It may be asked which is the root and which the transposed form. The answer is that the transposed form is usually local, and is shown to be later by the fact that modifications of it are absent or rare; whereas the real root is found all over the Pacific, and broken down forms of it are very common.

Of course, many forms of the same root may, and generally do, exist in one language. An instance may be given from Mota. The root *koro* means "to encircle, enclose"; hence, "to contract, shrink," &c. It is found in many Oceanic languages, as *koro*, *kolo*, *koko*, &c. Probably it is the source of the following words in Mota: *kolo* (contract), *koloi* (a hole), *kolkoloi* (a small contracted thing), *kor* (to shrink with heat or dryness, dried breadfruit), *koko* (keep close, contract, carry water in the hands), *kokor* (enclose, keep carefully), *kokos* (enclose, as fish in a net; fowls, by the people catching them), *kokot* (enclose, contract), *kokota* (narrow, contracted), *kokorou* (fold the arms or wings), *gogo* (shrink or shrivel), *gogorag* (gather together with the hands), *goro* (a preposition, with many meanings of enclosing or shutting-in), *goro-vag* (throw the arms round), *goro* (to cut round, and so generally to cut), *gorogoro* (harvest), *goro* (to embrace).

golo (fade or wither). There are other more doubtful examples of it, such as *oloolo* (a sacrifice), where probably (as in Efate *gorokoro*) the idea was that of protection, coming into the enclosure of the god sought and being shut out from the power of other gods.

Some examples of the application of these rules may now be given. Three roots will perhaps be sufficient to illustrate the subject.

Taking the Maori word *roto*, it is evident that we have the root itself. We may expect, however, to find it modified in various ways, and may look for it in such forms as *loto*, *oto*, *lo*, *ro*, *roro*, *lolo*, *toro*. The meaning of *roto* is "inside, within, the midst, places inland, a lake" (*ha rotoroto*, a pond). From this meaning of "within" (which is the root meaning) the word comes to mean in Samoa (in the form *loto*) "the heart, desire, or will; the understanding; the interior of a house: a deep pool in the lagoon" *loloto* (deep, depth), *lotoi* (to be in the middle). The Tahitian *roto* and Hawaiian *loko* have much the same meanings. In Tonga *loto* means "the mind"; *loloto* "deep, the deep, ocean." In Mangareva we get a further meaning for here *roto* is "deep, depth, the inward parts," and "to obscure or darken" while *rotoroto* is "the shallow sea," a curious meaning, to be explained presently. We may follow this full form of the root to Melanesia, where in Saa Malaita *roroto* is "a dark cloud"; in San Cristoval *rodo* is "dark," *rodomana* "the abode of the dead, the dark land"; and in Florida *rorodo* is "blind."

The form *oto* does not appear in Maori, but from the meanings presently to be given of the Maori *roro* it appears more than probable that *oto* has been modified into *uto*, which means in Tonga "the brains (the inner parts), the spongy substance of an old cocoanut"; the Mangareva *uto* (marrow, yolk of eggs); Mangaia *uto* (little kernel growing in a cocoanut); Fiji *uto* (heart, pith of trees, marrow of bones); Mota *utoi* (pith of trees); Malay *utak;* New Celebes *utok*. *Uta* (inland country), "forest" in many languages, is doubtless the same word. A final *o* is often represented in Malay by *a*, and in Malay *otak* means "brains" (*k* is a noun suffix in Malay).

We now come to *ro*, which appears in Maori, meaning "in, into"; and *lo*, which in Santa Cruz means "night or darkness." Taking next the reduplicated form of this, we find the Maori *roro*, meaning "brains or marrow." The Samoan *lolo* and Tahitian *roro* have similar meanings. The Hawaiian *lolo* means "the brain, marrow of bones, insane." Tongan *lolo* (oil, oily fat) and Mangareva *roro* (soft) are perhaps meanings derived from "the brain." In Santa Cruz *lolo* is "fat or oil"; in Mota *loloi* means "inside, the inner part, the affections," and is used in very many compound words to express states of feeling; *roro* means "deep, to sink down, be deep," also "to be sunk down," and so "shallow"; the water is said to *roro* in the well, hence the well is *roro* (shallow), an explanation of the Mangarevan word. *R* frequently becomes *n*, and there can be little doubt that *nonom* (to think) and *nonon* (to smear)—the *m* and *n* being verbal suffixes—are both from *roto*. In Efate, New Hebrides, *roro* means "to think," *rorona* "thought"; and Dr. McDonald mentions that these words are sometimes pronounced *trotro* and *trotrona*.

Taking now the final modification, the transposition of the letters, the Mota *toro* means "deep"; *toron*, "to desire or long for"; Florida *dolo*, "to love"; San Cristoval *doodoo*, "black"; *doa*, "blind."

In Oba, New Hebrides, *lologi* is "inside," and *rorogi* "deep"; in Malekula, *roror* is "deep," and *ror* "the afternoon" (*gi* and *r* are the noun suffixes in these two languages). The meaning "afternoon" is from the going down (*roro*) of the sun: the sun is said to *roro* in Mota when it sets. Many more examples of this root might be given, but enough has been written to show how it follows the rules given above.

The root which means "light and heat" is a difficult one to follow, because the two consonants it contains are interchangeable. It seems best to give *raho* as the root, though this form appears to have been lost, because the modified forms of *raho* (*aho*, *ao*, *ra*, *rara*) are the most widespread.

If we take *raho* as the root, with the meaning of "light and heat, the day, the sky, clouds," &c., we may expect to find several forms of the full root, because *r* and *h* are interchangeable letters, and *r* may become *l*, while *h* becomes *s* or *t*, and in the case of such a root it is difficult to say which is the transposed form; however, we may be guided by the number of modified forms which appear.

Laso the Kayan word for "heat," is a full form of the root, and so too, apparently, are *salo* (a cloud) in Saa Malaita, perhaps also *sato* (the sun) in Saa, and *warowaro* (the moon), in Saa *w* representing *h*, as it commonly does. The three last may be considered transposed forms of the root, and thus be classed with the New Guinea (Kerepunu) *haro* (the sun) and the Maori *Haronga* (a mythical sky-power who begot the sun and moon).

The modified forms we might expect to find by dropping the first consonant are *aho*, *aso*, *alo*, *aro*, and *ato*. The first four are found. *Aho* means "the sun" in Florida, and Ysabel (Solomon Islands), and Oba (New Hebrides). In Tongan it means "day"; while *ahoaho* means "bright or shining," as the moon on a clear night. The Maori *aho* means "radiant light," and *aho roa* is "the moon." *Aso* in Rotuma and Guadalcanar is "the sun"; in Samoa, "the day"; in Efate, "burning." *Alo* is "the sun" in New Celebes (*mata-alo*) and in Santa Maria. *Aro* is "the sun" in Hula and Bula'a (New Guinea), "the sky" in San Cristoval; while the Malagasy *maso adro* (the sun) is almost identical.

We get two forms by dropping the last vowel—the Mota *sar* (to shine, give heat) and the Aneityum *lah* (light) and *lav* (to shine).

Dropping the second syllable gives *ra* and *la*. *Ra* (the sun) in Maori is said to be the son of *Haronga* and the sister of *Marama* (the moon), a very exact account of the words, except that *marama*, from the root *rama*, is quite distinct from *raho*, and occurs along with it in many forms in many Oceanic languages. *Ra* in Maori also means "the day" and "the east." In Samoan *la* means "the sun, daylight; to be intensely hot." The words, with these meanings, are common in Polynesia.

Reduplicating the first syllable, we get *rara* and *lala*. In Maori *rara* means "to spread out on a stage to dry," and hence the stage itself. In Tahiti the word means "to scorch over a fire"; *rarararauri*, "sunburnt" (*uri* black); Fiji *rara*, "to warm one's-self by a fire"; Mota *rara*, "to dry or warm by the fire"; *rarang*, "to dazzle by reflection"; *rarangiu*, "hard dry ground"; *ma-rang*, "barren ground, lazy." In New Guinea the Motu *raraia* is "to dry in the sun"; Wedau *arara*, "to shine"; *arai*, "to burn"; Celebes *rarang*, "to dry." The Florida *ma-rara* means "light"; Mota *ma-rarara*, "transparent, translucent"; Malay *arang* means "charcoal." Samoan *ma-lala* is "charcoal"; Tongan *lala*, "to broil"; *ma-lala*, "charcoal"; Kayan *lala*, "to wither"; Wedau, New Guinea, *lalai*, "light"; Mahaga, Ysabel, *lalaha*, "light"; New Celebes *lalav*, "scorch"; Mota *lalav*, "scorch, burn"; *lawa*, "blaze or flame; to be red, brilliant in colour."

By dropping both consonants we get *ao*, the Maori "day, dawn, become light, cloud"; Tahitian "day, bright clouds, the bright land of heaven." In Mangareva we get *a*, meaning "sun," where remarkably little remains of *raho!*

Unusual forms such as *elo* ("sun" in the New Hebrides), *loa* ("sun" in Mota, "cloud" in San Cristoval), have not been referred to.

Perhaps it may be allowed to make two conjectures in conclusion. *Mano* means in Mota "famine": may this be *ma ao*, and mean "a time of sun without rain, when the ground becomes hard and dry" (Hawaiian *malo* "to dry up as water, to wither as a tree"; Mangaia *maro*, "hard and dry"; Mangareva *maro*, "hard")? Mr. Elsdon Best gives the Maori *tau maro* as "a year in which there are no crops."

The word *tataro* in Mota means "a prayer." Dr. Codrington writes thus of it: "The *tataro* of the Banks Islands, which may be called 'a prayer,' is strictly an invocation of the dead, and is, no doubt, so called because the form begins with the word *tataro*, which certainly is the '*ataro* of San Cristoval—that is, 'a ghost of power.' The Banks-Islanders are clear that *tataro* is properly made only to the dead, yet the spirits (*vui*, Qat and Marawa) are addressed in the same way." *Ataro* means "a god" in San Cristoval (*tidalo* in Florida, *tidatho* Ysabel, *tida'o* Guadalcanar). "The soul" in Malaita is *akalo*. In Samoan *tatalo* is "to pray" (Tahitian, *tarotaro*; Hawaiian, *kalokalo*; Tongan, *talo-monu*, "solicit by actions the favour of the gods," *talotalo*, "cast lots"). Apparently the meaning of *taro* was "a spirit or ghost." A man's spirit was perhaps thought to pass to the sky; he was no longer a *ta-nun*, a living man, but a *ta-mate*, a dead man, or a *ta-taro*, an inhabitant of the heavens; so in Florida he was no longer *ti-noni*, but *ti-dalo*. In the same way the soul was called *akalo*, just as *ata* in Samoan means "a spirit" or "the light"; Tahitian *ata*, "a cloud, a shadow, a certain prayer"; Tongan *ata*, "the air, free, the morning light, a shadow, reflection"; Maori *ata*, "early morning, the soul, a reflected image"; Motu (New Guinea) *vata*, "a ghost"; Mota *atai*, "soul." If *tataro* meant originally "the spirits of the dead," it might easily be made to include other inhabitants of the heavens: or, if it meant "the gods," then, when ancestor-worship grew up, the term would come to include the ancestors of the tribe.

The root *bara* or *para* seems to mean "crosswise, lying across." Other full forms of the root are *pala, bala, vala, fala.* From these we should expect to get *ara* or *ala; pal, par,* &c.; *ba, pa,* &c.; *papa, baba,* &c.; and transposed forms such as *rapa* and *lapa.* As a matter of fact, all these forms are found.

The way in which the meaning becomes modified is quite intelligible: from "crosswise" we get such ideas as—an angle, a ladder, tongs, a fence, a barricade, the shoulder, layers or strata in rocks, and hence flat slabs and anything flat, or, with a slightly different advance of meaning, the sloping side of a mountain, or an axe where the blade is not only flat, but is set sideways, crosswise, unlike the adze. With these preliminary remarks as to the meaning, we may follow the changes of form.

In Wedau, New Guinea, *bara* is "bent"; *barabarana,* "a bend or angle"; *barabara,* "a shelf, a wall-plate." In San Cristoval "a fence" is *bara;* in Saa Malaita it is *para;* while *para'a* is "the side." The Fiji *baravi* means "the sea-coast, the side of an island or mountain"; Maori *para-hi,* "a steep slope or acclivity." The Mota *parapara* is "an axe," a recent use of the word, according to Dr. Codrington. The Formosa *parai* means "to fence"; the Malay *parai* "to go in zigzags, as a ship tacking." An island in the Banks Group is called *Ure-parapara*, "the island of steep slopes": the sea has entered the crater, the steep sides of which give the island its name. The Malay *parang* is "a chopper or chopping-knife," or to cut with one; and this is the Maori *para*, "to fell trees or cut down bush." In Mota, *para* also means "to go off at an angle"; *sus para* is "to crouch aside."

Pala means in Mota "to set stick across stick, to set across, wattle"; *pala ta vava*, "to strangle a man by pressing a stick across his throat"; *i-pala*, "tongs"; *palapala*, "scissors" (a recent word). In Florida *palapala* is "a ladder." In Malay *palang* is "a cross-bar or transverse beam." In Santa Cruz *pala-po* is "lightning" (*po* meaning "downwards" and also "red"). In Tonga *palaa* means "a piece of a reed fence": while in Samoa *pala'au* is "a wooden fence."

In Mahaga Bugotu *babala* is "crosswise"; *gai babala*, "across." *Vala* means in Mota "the fence of small stones round an oven." In Madagascar *vala* is "a wooden fence or partition." The Efate (New Hebrides) *vala* means "a ship's yards," because set crosswise; while *falafala* is "a ladder," which is made by fastening cross-sticks to a tree. *Vala* in Florida means "the shoulder"; *varat* in Mota "the purlin of a house."

Leaving now the full root, of which many more examples might be given, we come to *ara* and *ala*. In Mota *ara* means "to keep off," while *qe-ara* is "a fence." The Saa Malaita *ala* means "the shoulder." The Maori *arai* means "a veil, screen, or curtain; to block up": Mangaian *arai*, "to ward off"; Tahitian *arai*, "to interpose, obstruct"; Hawaiian *alai*, "to obstruct, to block up a door or passage by sitting in it, to form a circle round a person for defence, to defend." The Torres *pi ala* is "a fence round a garden."

By dropping the final vowel we get *par* and *pal*. *Par* means in Mota "to slice, cut," as in *Par mal*, the name given to a class of secret societies the members of which were wont to *par* a *mal* or young cocoanut and drink the milk in common, after which they were accounted brethren. *Pal* in New Britain means "a room" (just as *niu* in Mota means either "partition" or "room"); in Duke of York Island, "an outhouse"; in Raluana (New Guinea), "a house."

Dropping the second syllable we get *pa* and *ba*, exceedingly common and important forms. A few examples must suffice. In Fiji *bai* means "to fence round a town or garden," while *ba* is "a fish-fence." In Maori *pa* means "to block up, obstruct; a fort or stockade, a weir for catching eels, a barricade; to protect": Samoan, *pa*, "a wall": Tahitian, *pa*, "a fence or hedge": Hawaiian, *pa*, "hedge or fence in; the wall of a town": Paumotu, *pa*, "a rampart or bulwark."

The reduplication of this gives us *papa* and *baba*. In Malagasy *baba* is "a wall or fence in fortification"; Formosa, *babas*, "an earthen dam"; Tahitian, *papani*, "to block up"; Mota, *paparis*, "wall of a house"; Maori, *papa*, "to close up or fasten; the layers or strata of rocks." It is from this last that the idea of a slab may perhaps be derived, and so *papa* or *baba* commonly means "a slab, board, anything flat." In Wedau, New Guinea, *baba* means "slab, side of big canoe"; *babai*, "to build up with slabs"; *babana*, "canoe built with timbers"; Maori, *papa*, "anything broad or flat—a slab, board, door, or shutter"; Samoan, *papa*, "board, floor-mat"; Tahitian, *papa*, "a board, seat, the shoulder-blade"; Mangareva, *papa*, "foundation"; Motu, New Guinea, *papapapa*, "flat rock"; Celebes, *papang*, "a board"; Malay, *papan*, "a plank or board"; San Cristoval, *paparagan*, "surf-board"; Malaita, *baba*, "surf-board." *Papa* means also "the earth" in Maori, and no doubt the Maoris conceived of the earth as flat, as our own forefathers did; this word however, may be from a root meaning "soil."

Taking last the transposed forms *rapa* and *lapa*, we get the Maori *raparapa*, meaning "the flat part of the foot"; Hawaiian *lapa*, "a ridge of land between two ravines, steep side of a ravine, having a flat or square side": Samoan *lapa*, "flat"; Mangareva *raparapa*, "flat", Paumotu *rapa*, "flat blade of paddle": Motu, New Guinea, *ilapa*, "a sword"; Mota *irav*, "a board, slab of wood in canoe or house"; *lapuai*, "the flat of a blade, tail of eel."

These roots are merely given as examples of the working-out of certain principles of comparison. Other roots might be easily given from which a still larger number of words are derived. But the following of such principles as those given above should make comparisons at once easier to obtain and more likely to be correct.

Confusion is especially likely to arise when the first syllable only remains, or where it has been reduplicated. For example, the Maori *ta* has many meanings, because it is derived from a number of different roots. *Papa* may be derived from *patu* (a stone or rock), *para* (across), *para* (sediment, dirt, &c.); *rara* from *rana*, *raho*, &c.; *roro* from *roto*, *rongo*, &c. If comparisons are to be sound, they should always have regard to the root-form and its meaning.

The study of the Oceanic languages should throw more light on the general problem of language than the study of the Aryan family or the Semitic, because the problems to be solved are less complicated, owing to the fact that the peoples have been living isolated for so long, and have been unaffected by civilisation. When the Oceanic family has been carefully studied, comparisons may be made with Aryan and Semitic languages. Apparently there were true Aryan and Semitic words in the original Oceanic language.

ART. II.—*List of Recent Shells found Fossil in New Zealand.*

By HENRY SUTER.

Communicated by Dr. Chilton.

[*Read before the Philosophical Institute of Canterbury, 3rd November, 1909.*]

DURING my recent study of the New Zealand *Mollusca* I made a list of species which have been recorded as fossil, and it may be of interest to have it published.

P. stands for Pliocene, M. for Miocene, O. for the Oamaru Series.

The latter formation was considered by Zittel to belong to the Oligocene or Upper Eocene, by Hutton to the Oligocene, whilst Professor

J. Park classed it under the Miocene. Tate, Harris, and Von Ihering, however, consider it to belong to the Eocene.

1. *Acanthochites zelandicus*, Q. & G. P.
2. *Chiton pellisserpentis*, Q. & G. P.
3. *Acmæa dædala*, Suter. P.
4. *Scissurella rubiginosa*, Hutton. P.
5. *mantelli*, Woodward. P.
6. *Haliotis australis*, Gm. P.
7. *iris*, Martyn. M.
8. *Emarginula striatula*, Q. & G. P., M.
9. *Subemarginula intermedia*, Reeve. P.
10. *parmophoidea*, Q. & G. P.
11. *Fissuridea monilifera*, Hutton. P.
12. *Trochus chathamensis*, Hutton. P.
13. *tiaratus*, Q. & G. P.
14. *viridis*, Gm. P.
15. *Monodonta æthiops*, Gm. P.
16. *corrosa*, A. Adams. P.
17. *lugubris*, Gm. P.
18. *Cantharidus pupillus*, Hutton. P.
19. *purpuratus*, Martyn. P.
20. *sanguineus*, Gray. P.
21. *tenebrosus*, A. Adams. P., M., O.
22. *Monilea egena*, Gould. P.
23. *Calliostoma pellucidum*, Valenciennes. P., M.
24. *punctulatum*, Martyn. P., M.
25. *selectum*, Chemnitz. P.
26. *spectabile*, A. Adams. M., O.
27. *Lissospira corulum*, Hutton. P.
28. *Turbo smaragdus*, Martyn. P.
29. *granosus*, Martyn. P., M.
30. *Leptothyra fluctuata*, Hutton. P.
31. *Astræa heliotropium*, Martyn. P.
32. *Ethalia zelandica*, Hombr. & Jacq. P., M.
33. *Rissoa (s. str.) impressa*, Hutton. P.
34. *(Cingula) zosterophila*, Webster. P.
35. *Rissoina (s. str.) rugulosa*, Hutton. P.
36. *(Zebina) emarginata*, Hutton. P.
37. *(Eatoniella) olivacea*, Hutton. P.
38. *Cerithidea bicarinata*, Gray. P.
39. *Seila terebelloides*, Martens. P.
40. *Serpulus sipho*, Lamarck. P., M.
41. *Stephopoma nucleogranosum*, Verco. P.
42. *Cæcum digitulum*, Hedley. P.
43. *Turritella rosea*, Q. & G. P., M., O.
44. *pagoda*, Reeve. P., M.
45. *Carlottæ*, Watson. P., M.
46. *symmetrica*, Hutton. P., M., O.
    (=*kanieriensis*, Harris.)
47. *Struthiolaria papulosa*, Martyn. P., M., O.
48. *vermis*, Martyn. P., M.
49. *vermis tricarinata*, Lesson. P.

50. *Xenophora corrugata*, Reeve. P., M.
(= *neozelanica*, Suter.)
51. *Calyptraea scutum*, Lesson. P., M.
52. *alta*, Hutton. P., M.
53. *maculata*, Q. & G. P., M., O.
(*calyptraeformis* of authors, non Lamarck.
54. *Crepidula crepidula*, L. P., M., O.
55. *costata*, Sowerby. P., M.
56. *Natica zelandica*, Q. & G. P., M., O.
57. *australis*, Hutton. P.
58. *Polinices amphialus*, Watson. P.
59. *Ampullina undulata*, Hutton. P.
60. *Trichotropis clathrata*, Sowerby. P.
61. *Trivia australis*, Lamarck. P.
62. *Cymatium spengleri*, Chemnitz. P., M., O.
63. *Phalium achatinum pyrum*, Lamarck. P.
64. *Epitonium zelebori*, Dunker. P., M.
65. *Turbonilla zealandica*, Hutton. P.
66. *Odostomia* (*s. str.*) *bembix*, Suter. P.
67. (*Pyrgulina*) *rugata*, Hutton. P., M.
68. *Eulima treadwelli*, Hutton. P.
69. *Megalatractus maximus*, Tryon. P.
70. *Fusinus spiralis*, A. Adams. P., M.
71. *Latirus huttoni*, Suter. P.
72. *Vexillum rubiginosum*, Hutton. P.
73. *planatum*, Hutton. P.
74. *biconicum*, Murdoch and Suter. P.
75. *marginatum*, Hutton. P.
76. *Siphonalia nodosa*, Martyn. P., M., O.
77. *caudata*, Q. & G. M.
78. *dilatata*, Q. & G. P., M.
79. *mandarina*, Duclos. P., M., O.
80. *Euthria linea*, Martyn. P., M.
81. *linea traversi*, Hutton. P.
82. *littorinoides*, Reeve. P.
83. *striata*, Hutton. P.
84. *Cominella maculata*, Martyn. P., M.
85. *maculosa*, Martyn. P.
86. *nassoides*, Reeve. P., M.
87. *zealandica*, Reeve. P.
88. *lurida*, Philippi. P.
89. *virgata*, H. and A. Adams. P.
90. *huttoni*, Kobelt. P., M.
91. *costata*, Q. & G. var. P.
92. *Murex octogonus*, Q. & G. P.
93. *octogonus umbilicatus*, T. Woods. P.
94. *octogonus espinosus*, Hutton. P.
95. *zelandicus*, Q. & G. P., M.
96. *angasi*, Crosse. P.
97. *Trophon ambiguus*, Philippi. P.
98. *rugosus*, Q. & G. P.
99. *cheesemani*, Hutton. P.
100. *corticatus*, Hutton. P.

101. *Trophon plebejus*, Hutton. P.
102. *bonneti*, Cossmann. P.
103. *Thais succincta*, Martyn. P.
104. *Admete trailli*, Hutton. P.
105. *Mitrella choava*, Reeve. P.
106. *Alcira transitans*, Murdoch. P.
107. *varians*, Hutton. P.
108. *Fulguraria arabica*, Martyn. P., M., O.
109. *arabica elongata*, Swainson. P., M., O.
110. *gracilis*, Swainson. P., M.
111. *Ancilla australis*, Sowerby. P., M., O.
112. *australis pyramidalis*, Reeve. P.
113. *depressa*, Sowerby. P., M.
114. *mucronata*, Sowerby. P.
115. *Marginella albescens*. Hutton. M.
116. *Drillia novæ-zelandiæ*, Reeve. P.
117. *lævis*, Hutton. P.
118. *trailli*, Hutton. M.
119. *Mitromorpha striata*, Hutton. P., M.
120. *Bathytoma albula*, Hutton. P., M.
121. *cheesemani*, Hutton. P.
122. *nodilirata*, Murdoch and Suter. P.
123. *Mangilia dictyota*, Hutton. P.
124. *protensa*, Hutton. P.
125. *sinclairi*, E. A. Smith. P.
126. *Daphnella cancellata*, Hutton. P.
127. *Terebra tristis*, Deshayes. P.
128. *Pupa alba*, Hutton. P.
129. *Tornatina pachys*, Watson. P.
130. *Volvulella reflexa*, Hutton. M.
131. *Cylichnella striata*, Hutton. P., M.
132. *Amphibola crenata*, Martyn. P.
133. *Endodonta coma*, Gray. P.
134. *Dentalium nanum*, Hutton. P.
135. *opacum*, Sowerby. P., M.
(*conicum*, Hutton.)
136. *Dentalium ecostatum*, T. W. Kirk. P., M.
137. *Nucula nitidula*, A. Adams. P., M.
138. *Leda bellula*, A. Adams. P.
139. *fastidiosa*, A. Adams. P., M.
140. *Malletia australis*, Q. & G. P., M.
141. *Poroleda lanceolata*, Hutton. P.
142. *Anomia huttoni*, Suter, n. sp. P., M., O.
(= *alectus*, Hutton, non Gray.)
143. *Anomia undata*, Hutton. P., M., O.
(= *cytæum*, Hutton, non Gray.)
144. *Anomia walteri*, Hector. P.
145. *Placunanomia zelandica*, Gray. P., M.
(= *ione*, Gray.)
146. *Arca decussata*, Sowerby. P., M., O.
147. *Glycymeris laticostata*, Q. & G. P., M., O.
148. *velutina*, Suter. P., M.
149. *Mytilus canaliculus*, Martyn. P., M.

150. *Mytilus magellanicus*, Lamarck. P., M., O.
151. *Modiolus australis*, Gray. P., M.
152. *Modiolaria impacta*, Hermann. P.
153. *Pecten medius*, Lamarck. P., O.
154. *radiatus*, Hutton. P., M.
155. *zelandiæ*, Gray. P., M.
156. *convexus*, Q. & G. P., M.
157. *Lima lima*, L. P.
158. *angulata*, Sowerby. P.
159. *bullata*, Born. P., M., O.
160. *Ostrea angasi*, Sowerby. P., M., O.
161. *hyotis*, L. P.
162. *corrugata*, Hutton. P., M.
163. *Atrina zelandica*, Gray. P., M., O.
164. *Crassatellites obesus*, A. Adams. M.
165. *Cardita calyculata*, L. P.
166. *Venericardia australis*, Lamarck. P., M.
167. *difficilis*, Deshayes. P., M.
168. *zelandica*, Deshayes. P.
169. *Loripes concinna*, Hutton. P., M.
170. *Divaricella cumingi*, Adams and Angas. P., M., O.
171. *Diplodonta zelandica*, Gray. P., M.
172. *globularis*, Lamarck. P.
173. *Erycina parva*, Deshayes. P.
174. *Diplodon menziesi aucklandicus*, Gray. P.
175. *Tellina eugonia*, Suter. P., M.
(=*angulata*, Hutton, non Gmelin.)
176. *Tellina disculus*, Deshayes. P.
177. *alba*, Q. & G. P., M.
178. *glabrella*, Deshayes. P.
179. *Leptomya lintea*, Hutton. P.
180. *Mesodesma subtriangulatum*, Gray. P., M.
181. *australe*, Gm. P., M.
182. *Mactra scalpellum*, Reeve. P.
183. *discors*, Gray. P., M.
184. *elongata*, Q. & G. P., M.
185. *ovata*, Gray. P.
186. *rudis*, Hutton. P.
187. *Spisula ordinaria*, E. A. Smith. P.
188. *æquilateralis*, Deshayes. P.
189. *Zenatia acinaces*, Q. & G. P., M.
190. *Dosinia lambata*, Gould. P., M.
191. *anus*, Philippi. P.
192. *subrosea*, Gray. P., M.
193. *greyi*, Zittel. P., M.
194. *Macrocallista multistriata*, Sowerby. P., M., O.
195. *Cytherea oblonga*, Hanley. P., M.
196. *subsulcata*, Suter. P.
197. *Chione stutchburyi*, Gray. P., M., O.
198. *yatei*, Gray. P.
199. *crassa*, Q. & G. P., M.
200. *mesodesma*, Q. & G. P., M.
201. *Paphia intermedia*, Q. & G. P., M.

202. *Protocardia pulchella*, Gray. P., M.
203. *Psammobia lineolata*, Gray. P., M., O.
204. *stangeri*, Gray. P., M.
205. *Soletellina nitida*, Gray. P., M.
206. *Corbula macilenta*, Hutton. P.
207. *zelandica*, Q. & G. P.
208. *Saxicava arctica*, L. P.
209. *Panopea zelandica*, Q. & G. P., M.
210. *Pholadidea spathulata*, Sowerby. P.
211. *Barnea similis*, Gray. P.
212. *Thracia vitrea*, Hutton. P., M.
213. *Cochlodesma angasi*, Crosse and Fischer. P.
214. *Myodora antipodum*, E. A. Smith. P.
215. *boltoni*, E. A. Smith. P.
216. *novæ-zealandiæ*, E. A. Smith. P.
217. *striata*, Q. & G. P.
218. *subrostrata*, E. A. Smith. P., M.
219. *Chamostrea albida*, Lamarck. P., M.

ART. III. *Botanical Notes made on a Journey across the Tararuas.**

By BERNARD CRACROFT ASTON, F.I.C., F.C.S.

[*Read before the Wellington Philosophical Society, 1st September,* 1909.]

THE portion of the Tararua Range treated of in this narrative may be viewed from Wellington, stretching beyond the Upper Hutt Valley. At the southern end is seen the rounded outline of Mount Marchant (3,406 ft.). followed, more to the north, by three much lower conical-topped hills; then a conical mountain stands out nearer the beholder than the conical hills, and on a level with Mount Marchant. The Quoin (3,905 ft.), the southern termination of a high range leading to Mount Hector, is not discernible in the outline of hills, being overtopped and rendered invisible by Mount Alpha (4,466 ft.). Finally, after a fairly level stretch of country, there succeed a few ragged peaks, near which is the remarkable razorback ridge (to be presently described) overshadowed by Mount Hector (5,014 ft.), the highest peak which can be seen. Descending on the Otaki side there are some rounded summits (4,700 ft.), and at a much lower elevation Mount Dennan (4,010 ft.). Below this is a saucer shaped depression ("Table Top") rising on the Otaki side to a rounded knob, the last peak silhouetted against the sky.

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* Some of the information contained in this account is drawn from experience acquired on trips other than those herein described. Chronologically enumerated, the author's acquaintance with these mountains is derived from—(1) A three-days trip to Mount Holdsworth with Professor Easterfield, Dr. L. Cockayne, and Mr. A. H. Cockayne, in January, 1906; (2) a three days solitary ramble on Mount Dennan and in the Otaki Gorge, in December, 1906; (3) a three-days ascent of Mount Hector from Otaki, in January, 1907, with Messrs. D. Petrie, A. Hamilton, J. S. Tennant, W. C. Davies, and Alfred Jones; (4) a three-days journey on Mount Holdsworth, in March, 1907, with Messrs. G. de S. Baylis and Turners (two); (5) three days on Mount Holdsworth with Messrs. D. Petrie and J. S. Tennant, in January, 1908; (6) the crossing of the range here described; (7) a two-days trip up the Hutt Gorge with Mr. John Onilwell, in November, 1908; (8) a partial ascent of Mount Dennan with Messrs. C. O'Connor and Simmonds, at Easter, 1909; (9) an ascent of the Quoin, *via* the ridge, in June, 1909, with Mr. E. Phillips Turner.

Since writing this paper the author, with Mr. W. H. Field, M.P., and Mr. L. Phillips, of Kaitoke, on 12th February, 1910, crossed from Kaitoke to Otaki Gorge settlement in twenty-four hours actual walking-time, the journey occupying, including the time taken for sleep, only thirty-six hours. The Kaitoke ridge track was followed, the route otherwise being as described above. The high levels were obscured by mist, which, however, occasionally lifted. Abundance of water was found, as before.

The writer cannot find any record of a collector or naturalist having crossed the range from Kaitoke to Otaki. Indeed, even Mount Hector would appear not to have been botanically explored until December, 1906 (see Petrie, "Account of a Visit to Mount Hector": Trans. N.Z. Inst., 1907, p. 289), when the writer made his first collection there.

Leaving Wellington by the 7 a.m. train on Boxing Day, 1907, Kaitoke is reached about 9 a.m. The day is fine a light breeze from the north east, blue sky with patches of cloud, and a barometer of 30·1 in., giving presage of fair weather for the venture. The party consists of Mr. Alfred Jones (an expert bushman), W. B. Aston, and the writer. The swags include 5 lb. boiled beef, 3 lb. ham, 5 lb. ship-biscuits, a small loaf, 2 lb. oatmeal, 2 lb. sugar, ¾ lb. butter, a little tea, chocolate, and raisins, collecting-boxes, drying-papers, a blanket each, and a tent. The tent is worthy of a brief description. It weighs under 1 lb. dimensions 5½ ft. by 7½ ft.—and includes a flexible wire rope used instead of a ridge pole. One end of the rope is fixed to a tree, and the other is threaded through the apex of the tent-roof and fixed to another tree. All that now remains is to fasten the guy-ropes, made of light fishing-line, to stumps, &c., near the ground, and peg down the sides. The advantage of having a light and easily pitched tent such as this in climbing-expeditions, where everything has to be carried on one's back, can hardly be overestimated. The tent is made by Messrs. Hutcheson, Wilson, and Co., Jervois Quay, and is similar to those supplied to the Tourist Department for alpine climbers, with the exception that it has no floor. The material is that of which the fine topsails of yachts are made, technically known as japarra—an Egyptian fabric.

At least three routes are open to the explorer of the Tararuas from Kaitoke. The Mount Marchant track involves climbing the bare ridge connecting the Rimutakas with the Tararua Range, and following the spur over Mount Marchant, thence taking a large sweep to the north-east over many lesser tops on the high range by a track marked on the map "well blazed" to Mount Omega (3,669 ft.), between which and Mount Alpha (4,466 ft.) there remains a deep valley to be crossed before attaining the high leading range of which Mount Hector is the culminating point. The writer is informed that it is not necessary to climb to the top of Mount Marchant, but that the spur may be attained on the farther side by a passage through the bush on the north-east flank of the mountain.

The second and third routes are the same with the difference that the first few miles is over a spur—four hours' walk—or through the river gorge—nine and a half hours' walk—at the traveller's discretion, to the junction of the Main Hutt with the Lesser Hutt River. The spur route is always available, and is remarkably easy travelling, through dead standing bush which was swept by the fires of last year and completely denuded of underscrub. One should take the hill at the back of Phillips's hut (650 ft.), near the mouth of the Pakuratahi Gorge, and, steering due magnetic north, two and a half hours' walk on the ridge brings one to the summit of the hill (2,000 ft.), where Mount Marchant looms largely ahead, and the lower slopes of the Quoin are seen on the left in the angle formed by the junction of the rivers. The Lesser Hutt Gorge is from this aspect visible for a considerable distance. Descending the hill, still through burnt standing timber, another one and a half hours' walk should bring one to the base of the Quoin.

The gorge route, on the other hand, takes at least nine hours' laborious walking, the times taken on the two occasions the writer traversed the route being nine hours and a half and nine hours and a quarter from Kaitoke to the junction; and it is not accessible if the river is in flood. The advantages of going this way are the beautiful scenery, the impossibility of mistaking the way, and the facility for studying the various forms of life met with in the forests of the banks and in the unfished waters of the rivers.

Crossing, to the north of the Kaitoke Station, some flat country where agriculture is being practised, judging by the Californian thistle, blackberry, and gorse which impeded progress, the Pakuratahi Gorge is soon reached, and little time is lost in finding the track, which leads off from behind a blue cliff-face on the south side of the river. Numerous shapely ribbonwood-trees (*Plagianthus betulinus*), which always attain their finest growth on silty alluvial soil, are observed growing on the flats. The track is excellent, and leads through a very mixed forest, of which the plants noted in the appended list are observed.

After a mile or so of this track the forest undergoes a distinct change. Red-beech (*Fagus fusca*) is now the predominant growth — in fact, it is almost the only tree-growth, being supplemented only to a slight extent by miro (*Podocarpus ferrugineus*). The underscrub consists of *Coprosma Colensoi*, *Griselinia littoralis*, *Leucopogon fasciculatus*, *Coprosma grandifolia*, *Pseudopanax crassifolium*, *Myrsine salicina*, *Panax arboreum*, *Coprosma fœtidissima*, *Myrtus pedunculata*, and *Metrosideros florida*, while the forest-floor is covered with *Gahnia*. *Gleichenia Cunninghamii* (umbrella-fern), and moss. Here and there on stumps are patches of the beautiful *Earina mucronata*, the blue-berried *Dianella intermedia*, and a variety of ferns, mostly kidney-ferns (*Trichomanes reniforme*). The tree-trunks are covered with climbing ratas (*Metrosideros hypericifolia* and *M. Colensoi*), epiphytic growths, filmy ferns, polypodies, asteliads, *Tmesipteris*, and orchids (*Earina mucronata* and *E. suaveolens*).

The path wanders for some distance through this light open forest, and then descends suddenly to the junction of the Pakuratahi and Hutt Rivers. Here the steep banks are sprinkled with bright flowering shrubs and herbs. Prominent are *Carmichaelia odorata*, with masses of sweetly scented purple-blue flowers and graceful pendulous branches, while *Veronica catarractæ*, *Gnaphalium Keriense*, *Oxalis magellanica*, *Pratia angulata*, and *Libertia ixioides* brighten the steep mossy banks with their large white flowers.

The forest is thicker here, and the spaces are well filled with scrub and small trees. Rimu and kamahi (*Weinmannia*) are the prevailing trees, with a shrubbery of *Fuchsia*, *Pittosporum*, *Veronica salicifolia*, *Schefflera*, and *Coprosma*; and along the banks the free-flowering *Olearia nitida*, toitoi (*Arundo conspicua*), and wood-grass (*Microlæna avenacea*) are plentiful, and a few patches of snow-grass (*Danthonia Cunninghamii*).

A walk of an hour and a half brings one from the Kaitoke Station to this charming spot, where but a couple of years ago was pitched a survey camp, by the work of whose vanished tenants one wishing to advance into the wilds may largely profit.

Crossing the Pakuratahi, we soon leave all vestige of a track behind and plunge up the Hutt River. Here and there blazes on the trees are met with, and occasionally one comes across a track cut over the bluff forming one of the walls of some impassable gorge between which the waters rush as through a mill-sluice. The river bends with monotonous frequency, which necessitates incessant crossing to take advantage of the shingle bank or rocky ledge on the opposite side, in order to gain a few chains advance; thus, sometimes wading up to one's middle, scrambling over slippery rocks, hanging on by bough, tussock, or pendant kiekie (*Freycinetia*), always striving to keep the food and blankets, strapped shoulder-high, dry, slow progress is made. Anon one of the party slips from the rock into some deep pool, and the water surges round the knapsack; but the biscuits, contained in a tin case, are safe, and the victim slowly and laboriously draws himself out of the swift current, and drains himself on the bank. Occasionally the spirit of sport asserts itself, and a halt is called to watch some monster of a trout or eel, the solitary inhabitant of a deep pool, lazily disporting himself.

The rock scenery of the gorges is truly grand. Cut into fantastic shapes by the current when in flood, here and there a mass of rock which has survived the eroding force of the river stands out in bold relief, often with some narrow defile for a background through which the river rushes with deafening surge. Pockets and pot-holes in the rock hold a lodgment of silty soil, supporting many beautiful plants Prominent is *Carmichaelia odorata*, *Veronica cataractae* (well named), *Microlæna avenacea*, *Pratia angulata*, *Hydrocotyle* sp., *Coriaria ruscifolia* *Gnaphalium Keriense* sometimes the rare *Calceolaria repens*, and similar plants requiring a moist, well-drained alluvial soil

Feathered friends are not wanting to break the stillness of the bush Once a pair of blue mountain-duck were startled from the bank, and swam leisurely down stream, uttering expostulatory quacks against the intruders of their fastness. The quaint little rifleman is observed in numbers, running up the sides of the trees and snapping up many a toothsome morsel with its upwardly inclined bill, whistling from time to time a cheerful twit. The tui's musical note is often heard, contrasting strongly with the long-tailed cuckoo's screechy pipe. Fantails flutter here and there, and occasionally a handsome pigeon laboriously wings its musical flight from tree to tree.

Presently the gorge opens out, and light floods the valley. We are nearing the confluence of the Hutt and the Lesser Hutt Scrambling down a steep face, a fine river-beach is reached at 6 30 p.m. Camp is soon pitched, and a hearty meal enjoyed This camp is about 800 ft. altitude is not greatly different from that of Kaitoke.

A visit to this camp in November, 1908, when the faint odour of the rangiora (*Brachyglottis repanda*) was in the air, and the spring flowers had shaken out their petals to the full, showed us many whiteheads, tomtits, riflemen, pied fantails, grey warblers, a pair of grey duck, flocks of chaffinches, many pigeons, kaka, parrakeets, tuis, long-tailed cuckoos, and in the still hour of the early dawn a woka visited the tent, was disturbed, and stalked up the valley, waking the echoes with its vibrant call.

Bluffs and Beeches on the Hutt River

Confluence Camp, junction of the Main and Lesser Hutt Rivers, foot of Quoin.

BOTANY OF THE TARARUAS.—Aston.

Face p. 11.

B. C. Aston, photo.

Effect of wind action on Quoin top, cutting vegetation (*Danthonia Raoulii, Dracophyllum longifolium, Celmisia spectabilis, Pimelea Gnidia, Drapetes Dieffenbachii, Senecio lagopus*) into lanes.

Scrub on Quoin top consisting of *Coprosma cuneata, C. foetidissima, Olearia lacunosa, O. Colensoi, Astelia nervosa, Senecio elaeagnifolius, Danthonia Raoulii* (Snowgrass).

BOTANY OF THE TARARUAS.—Aston.

B. C. Aston, photo.

Mountain tarn on Quoin top with Cushion plants and Snowgrass.

Mount Alpha and ridge leading from Quoin top. *Fagus Menziesii* trees deeply covered with lichens and mosses to topmost bough.

BOTANY OF THE TARARUAS.—Aston.

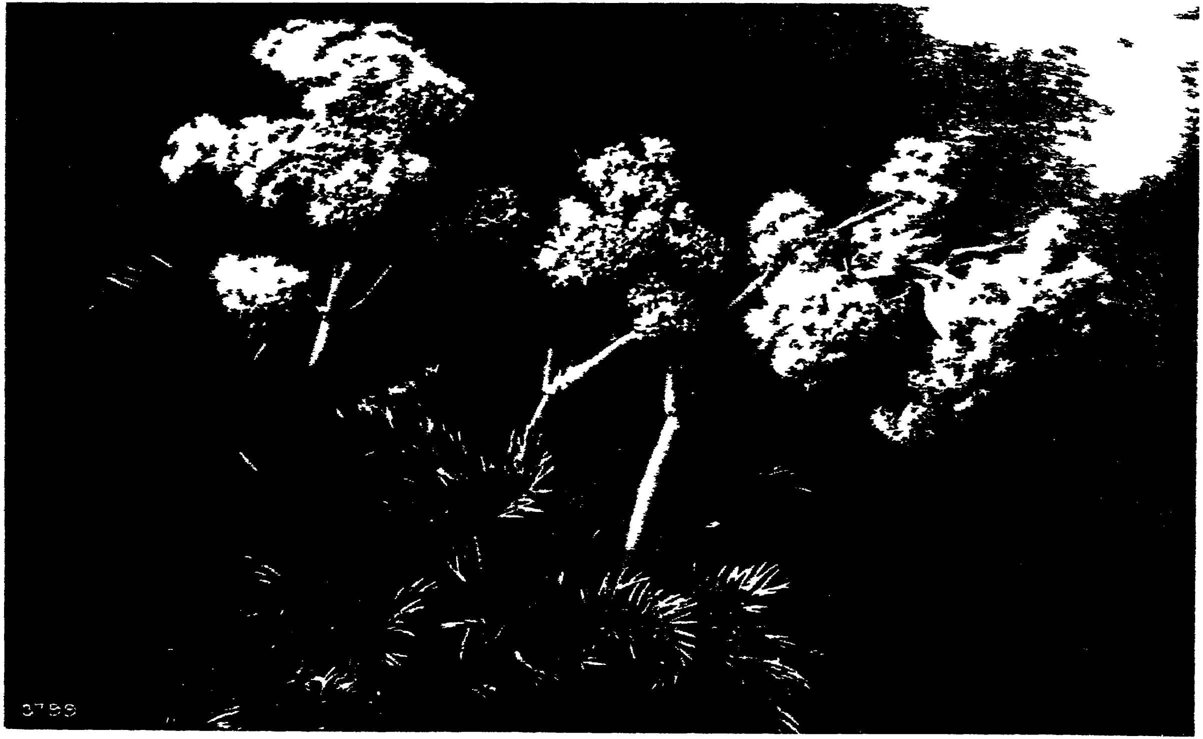
B. C. Aston, photo.

Mount Hector Range from Quoin top, with Mount Hector in the distance.

Astelia nervosa beds on summit of Quoin. The darker patches are composed of *Coprosma cuneata* and the lighter of *Dracophyllum* and *Danthonia Raoulii* (Snowgrass).

BOTANY OF THE TARARUAS.—Aston.

B. C. Aston, photo.



Ligusticum dissectum, a characteristic and abundant plant of the Tararuas—its only known habitat.

BOTANY OF THE TARARUAS.—ASTON.

W. C. *Davies, phot.*

Helichrysum grandiceps (New Zealand Edelweiss) [illegible] above 4

BOTANY OF THE TARARUAS.—ASTON.

[illegible] D

Mouth of the Pakaiutahi. Heketara (*Olearia Cunninghamii*) in flower.

Shingle beds on the Pakaiutahi River.

BOTANY OF THE TARARUAS.—Aston.

B. C. Aston, photo.

A list of plants seen from the junction of the Pakuratahi and Hutt Rivers to the camp is given below: *Pittosporum eugenioides, P. tenuifolium, Hoheria populnea, Oxalis magellanica, Coriaria ruscifolia, Carmichaelia odorata, Weinmannia racemosa, Gunnera monoica, Myrtus obcordata, Fuchsia excorticata, Hydrocotyle elongata, Schefflera digitata, Griselinia littoralis, Coprosma robusta, Lagenophora Forsteri, Olearia nitida, Gnaphalium Keriense, Helichrysum glomeratum, Senecio latifolius, S. lagopus, S. Kirkii, Pratia angulata, Calceolaria repens, Veronica catarractæ, V. salicifolia, Ourisia, Piper excelsum, Laurelia novæ-zealandiæ, Beilschmiedia tawa, Knightia excelsa, Fagus Menziesii, Podocarpus ferrugineus, Dacrydium cupressinum, Corysanthes, Dendrobium Cunninghamii, Thelymitra* sp., *Earina autumnalis, Cordyline Banksii, Dianella intermedia, Danthonia Cunninghamii, D. semiannularis, Deyeuxia, Hymenophyllum multifidum, Asplenium flaccidum, Adiantum affine, Lomaria alpina, L. vulcanica, L. Patersoni, Microlæna avenacea.*

An early start is made next morning, with fair weather and a rising barometer. At 5 a.m. the Lesser Hutt River is crossed, and the ascent of the steep leading spur to the Quoin is begun. But few supplejacks—the bane of the bushman—impede the way. The forest is chiefly kamahi, with beech, rimu, and a little totara and rata. The forest-floor is carpeted with umbrella (*Gleichenia Cunninghamii*) and kidney (*Trichomanes reniforme*) fern. At 1,100 ft. *Senecio Kirkii* appears as a plentiful underscrub; at 1,400 ft. totara is more plentiful, and the floor is a perfect carpet of kidney-fern, with clumps of *Astelia nervosa* dotted through it. The kamahi (*Weinmannia racemosa*) is still the predominating tree; occasionally a miro (*Podocarpus ferrugineus*) is seen, its bright-red fruit presently to afford a rich feast for the pigeons. The epiphytic orchids *Earina mucronata* and *E. suaveolens* are still plentiful, and *Gastrodia Cunninghamii*, the tall black-and-white flowered terrestrial orchid, with the large tuberous roots beloved of pigs, is met with. The ferns *Lomaria discolor* and *L. alpina* cover the ground in places. Here and there a spray of pure-white flowers shows where the beautiful little nohi (*Enargia parviflora*) wastes its sweetness on the desert-air. The underscrub is chiefly *Coprosma fœtidissima, C. lucida,* and *Myrsine salicina.*

At 1,600 ft. the forest is more open. There is a greater preponderance of light scrub, *Coprosma grandifolia, C. fœtidissima,* and *C. Colensoi.* Clumps of *Uncinia* appear.

At 1,700 ft. snow grass is plentiful on the floor of the forest, of which the chief tree is kamahi. *Leucopogon fasciculatum* and *Pseudopanax crassifolium* are common.

At 1,900 ft. *Panax simplex* becomes common.

At 2,100 ft. *Fagus fusca, Weinmannia, Senecio Kirkii, Coprosma Colensoi, Panax arboreum, Myrsine salicina,* filmy ferns (*Hymenophyllum*), and mosses are most conspicuous.

At 2,200 ft. the billy is boiled, the water being obtained from a puddle in a hollow. Hanging moss or lichen is now becoming a prominent feature on the trees. In wet places *Microlæna avenacea,* and in dark places *Todea superba* (double crape-fern), were plentiful.

Deep moss now covers the forest-floor. The trees are *Fagus fusca* and *F. Menziesii,* with a sprinkling of kamahi.

At 2,300 ft. the arboreal growth is more stunted, and the floor is carpeted with moss, nohi, and filmy fern. An open space here shows the top of the Quoin to be due (magnetic) north; but the ridge takes a considerable sweep to the east and back again to the north. This is the only part of the ascent where it is possible to go wrong; but, as one may obtain such a clear view of the country by climbing one of the stunted beeches, losing the way is a very unlikely contingency. The forest is *Fagus Menziesii* and totara, with a little *Fagus fusca.* The occurrence of *Phormium tenax* testifies to the open nature of the forest. *Lomaria discolor*, *L. capensis*, snow grass (*Danthonia Cunninghamii*), and *Gleichenia Cunninghamii* are abundant. The country here is fairly level, and, viewed from the top of a stunted tree, shows *Fagus Menziesii*, with *Dracophyllum longifolium*, with some *Fagus fusca* and totara, to be the main forest-growth. Occasional kamahi, *Myrsine salicina*, *Coprosma Colensoi*, and *C. fœtidissima* are present. The totaras are deeply mossed with lichens to the topmost bough.

Thence succeeds a wind-exposed slope, with stunted *Suttonia divaricata* and other scrub breast-high, with *Lycopodium* and stunted *Fagus Menziesii* and *Weinmannia.*

At 2,500 ft. to 2,600 ft. the beech and totara trees are very gnarled growths, with an underscrub of *Coprosma fœtidissima.*

At 3,000 ft. (12.20 p.m.) the forest is gnarled *Fagus Menziesii* 40 ft. high, with an underscrub of *Coprosma fœtidissima*, *Panax arboreum*, and *Suttonia divaricata.* *Astelia nervosa* is common. The broadleaf (*Griselinia littoralis*) here attains a height of 15–20 ft., being quite a small tree. *Hymenophyllum multifidum*, *Todea superba*, and moss cover the forest-floor. Kaka and bell-birds are seen.

At 3,100 ft. stunted *Fagus Menziesii* 14 ft. high at edge of bush, mossed to the topmost bough, forms the dominant growth. The underscrub is *Pittosporum rigidum*, *Senecio eleagnifolius*, and *Coprosma cuneata.*

3,150 ft. We are out at last, and breathe the fresh air on the open mountain-side. On the western face there is stunted *Fagus Menziesii* 3 ft. high, and snow-grass, and then an alpine meadow containing *Celmisia spectabilis* (in flower), *Carpha alpina*, *Drosera stenopetala*, *Caladenia bifolia* (in flower), moss, *Forstera* (in flower), *Pentachondra pumila*, *Pimelia Gnidia* (in flower).

3,350 ft. We encounter stunted scrub again on the south side of the spur, chiefly *Coprosma cuneata* and *Dracophyllum longifolium.*

On the east side the *Fagus Menziesii* creeps up to within 100 ft. of the top, and affords a grateful shelter from the fierce sun, the beech-trees being about 20 ft. high here. Directly one moves over to the western face the trees are beaten down to a height of 3 ft., making it difficult to force a passage through.

3,600 ft. On the west side of the spur *Olearia Colensoi* (the mutton-bird scrub) appears in thick shrubberies, broken by snow-grass meadows. *Ligusticum dissectum* is in full flower. Entering the forest on the west side to avoid the mutton-bird scrub, we meet with *Olearia alpina*, a handsome shrub of most characteristic growth, resembling the lancewood (*Pseudopanax crassifolium*). The floor of the forest is carpeted with filmy ferns and *Myrsine nummularia.* Good progress is made, and the top of the Quoin (3,900 ft.) is reached at 4 p.m. Although it has taken eleven hours to climb to this height, allowance must be made for the fact that we are carrying heavy swags, and are not in the best condition. The day has been very hot, and we are new to the route. Moreover, frequent rests for taking notes and observations have been resorted to.

Between the summit and the bush-line on the eastern face are a few acres of mountain-meadow containing many beautiful alpine plants. Among the most noticeable are *Aciphylla Colensoi*, *Ligusticum dissectum*, *Celmisia spectabilis*, *Raoulia grandiflora*, *Senecio bellidioides*, *Phyllachne Colensoi*, *Euphrasia revoluta*, *Suttonia nummularia*, *Gaultheria antipoda*, *Pimelia Gnidia*, *Dracophyllum rosmarinifolium*, *Astelia nervosa*, *Carpha alpina*. *Danthonia Raoulii*, *Ehrharta Colensoi*. In the wetter parts are clear pools of good water, surrounded by the interesting cushion-plant *Oreobolus pumilio* var. *pectinatus*, mixed with *Astelia linearis*, *Drosera stenopetala*, *Pentachondra pumila*, *Forstera* (?) *Bidwillii*, *Caladenia bifolia*, and *Caltha novæ zealandiæ*. A black bird, which may be a huia, is twice seen in the evening. A fine wild bull seems inclined to dispute possession of the summit with us. but, being left alone, towards sunset, after the manner of his kind, he makes his way down into the valleys. Long after dark we hear the distant lowing of his mates. This and the mournful notes of the ruru (morepork) are the only sounds which wake the stillness of our first night on the hilltops.

Sunday, 29th December. -We had witnessed the sinking of the sun into the south-western ocean the previous evening, and were this morning to see it rise from the sea in the opposite direction. An interesting phenomenon accompanied it. Before the edge of the sun appeared above the horizon. one-half of the disc appeared below the horizon-line and nothing above it, the effect being due possibly to reflection from a bank of clouds.

After breakfast we start to ascend the northern *arête* to Mount Alpha, and notice the rare *Abrotanella pusilla* in flower. The spur we now descend has been burnt on the west side, but on the east side is virgin scrub, merging gradually into forest. The way is fairly easy, though beds of *Astelia nervosa* occasionally impede us. The vegetation on this ridge is *Coprosma cuneata*, *Olearia lacunosa*, and *O. excorticata*, growing in great profusion; *Phormium tenax* (in flower), *Gaultheria antipoda*, *Ligusticum aromaticum*, and a stout species of *Uncinia*; while the only naturalised plant seen was *Hypochæris radicata* in the cattle-tracks. At the lowest point of the *arête*, 300 ft. below the Quoin-top, *Cordyline indivisa*, *Senecio eleagnifolius*, *Olearia nitida*, *Gaultheria rupestris*, *Hoheria populnea*, *Danthonia Raoulii*, *Ourisia Colensoi* are common.

At 3,800 ft. we commence the rise to Mount Alpha, and are on the open mountain-side, with no scrub. *Senecio Bidwillii* (in bud) becomes common, but *Ligusticum dissectum* is abundant.

At 4,000 ft. *Gentiana patula* (in bud), *Celmisia spectabilis*, *Oreomyrrhis andicola*, *Dracophyllum rosmarinifolium*, and *Ligusticum dissectum* are abundant. Pipits and fantails are seen.

At 4,200 ft. a small mountain-tarn gave us a grateful drink. *Celmisia hieracifolia* (in flower), *Ourisia cæspitosa*, *Veronica buxifolia* (in flower), *Drapetes Dieffenbachii* (in flower), patches of *Raoulia grandiflora*, *Helichrysum Leontopodium* (in flower), *Veronica Astoni*, *Bulbinella Hookeri*, *Aciphylla Colensoi* (in flower), *Epilobium* sp. (?), *Poa*, are the most noticeable plants. On the rocks are many specimens of the vegetable sheep of the Tararuas (*Raoulia rubra*).

At 4,450 ft. by our aneroid we top Mount Alpha, and discover several good mountain-tarns, but no firewood. There is the usual vegetation, comprising most of the species noticed, and one notable addition, *Celmisia hieracifolia* var. *oblonga*, a very diminutive variety of a handsome species, and now recorded for the first time in the North Island. Descending Mount Alpha a hundred feet or so, at 4,300 ft. another tarn is passed; then a climb over an unnamed peak of 4,450 ft. On the other side of this a remarkable instance of wind-action on vegetation is noticed. On a gentle slope trending towards the west, the ground-mass of which is angular stones, are lanes of herbaceous plants growing with a regularity which simulates artificial arrangement. The area of this would be about 3 or 4 square chains. There is a space of 6 ft. to 8 ft. between the strips of vegetation, containing angular stones with but little vegetation, save an occasional patch of *Raoulia grandiflora*, *Phyllachne Colensoi*, and *Drapetes Dieffenbachii*. The vegetation of the lane "hedge" is two species of *Danthonia* (one of which is *D. Raoulii*), *Ligusticum dissectum*, *Bulbinella*, *Phyllachne*, *Celmisia spectabilis*, *Dracophyllum*, *Ligusticum aromaticum*, *Astelia linearis* (in beautiful red fruit). These lanes run in an east-and-west direction. We have been traversing a long stretch of gently rising country, and, passing a tarn, arrive at a point 4,500 ft., the lowest point between the flat land and the ridge leading to Mount Hector. Patches of *Luzula campestris* frequently occur, and some stunted *Olearia Colensoi*, very fine plants of *Senecio Bidwillii*, snow-grass (*Danthonia*), and masses of *Raoulia rubra* on steep rubble slips, are the most noticeable botanical features.

We now ascend the remarkable razorbacked ridge. On the north-east face a *Danthonia* (snow-grass) meadow extends for several hundred feet down the slope. Scattered through the snow-grass are *Dracophyllum longifolium*, *Senecio Bidwillii*, *Bulbinella Hookeri*, *Aciphylla Colensoi*. On the south-west side is a steep shingle or rocky face covered in parts with *Raoulia rubra*, patches of *Ligusticum dissectum*, *Celmisia hieracifolia*, *Danthonia Raoulii*, and *Helichrysum Leontopodium*. The ridge is equally steep on either face, and where it changes its aspect in zigzagging the flora also changes: the *Danthonia* meadow now appears on the left-hand side, facing the north-east, and the rocky slope on the right hand, facing south-west, approximately, showing that the difference in vegetation is due to a climatic and not to an edaphic cause.

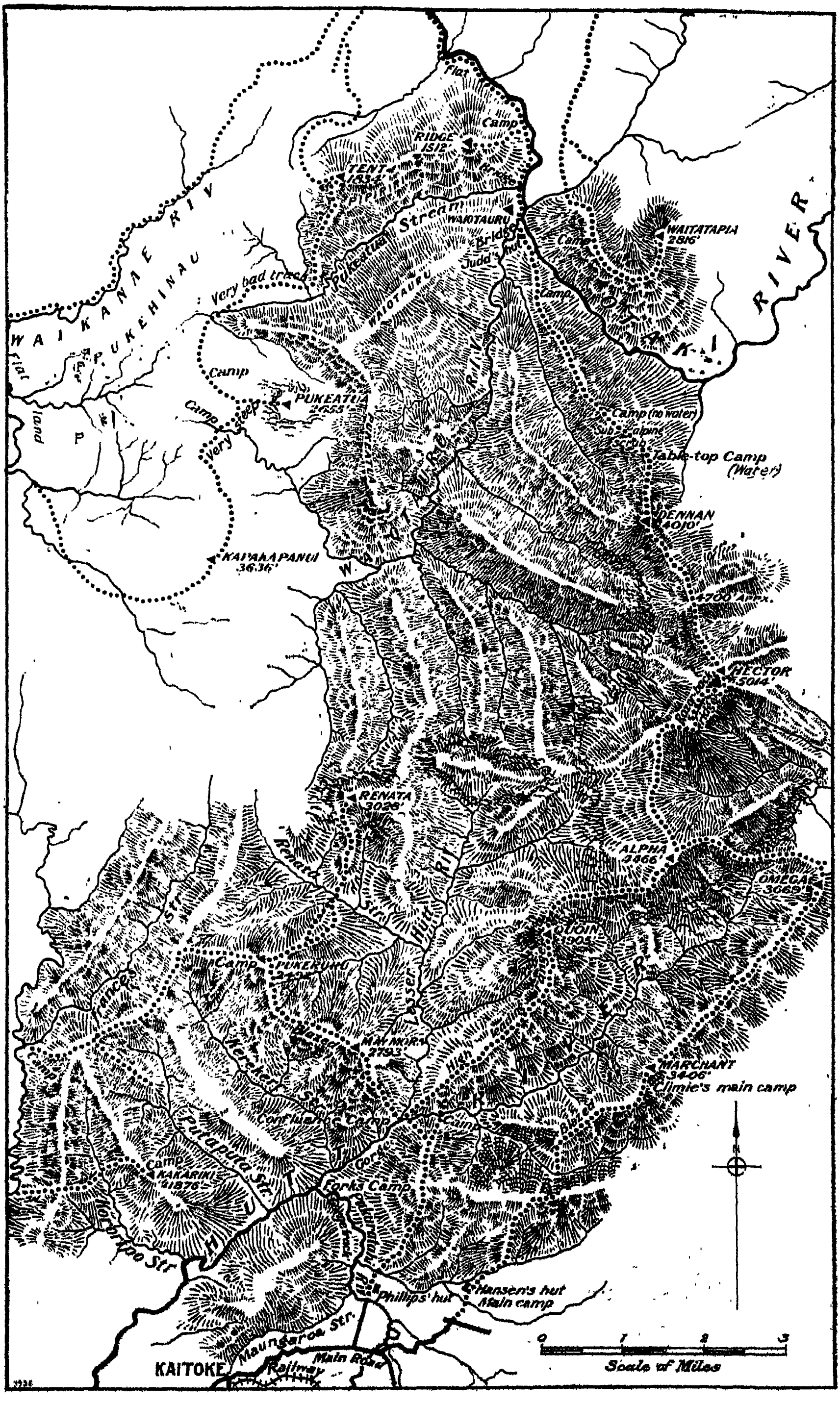
At 4,700 ft. the "razorback" disappears, giving place to a rounded hill, covered on the south-west slope with a lane formation similar to that previously described, and containing *Danthonia*, *Ligusticum*, *Phyllachne*, and *Celmisia spectabilis*.

At 4,800 ft., where the faces of the ridge again become steeper, are noticed stunted *Danthonia* and *Bulbinella* on the north-east face, and incipient lane formation on the south-west face; and again at 4,900 ft. is a rocky face on the south-west and *Danthonia* on the north-east face.

A plant we have noticed all the way from Mount Alpha is *Veronica Astoni*, usually found growing on the top of the ridge.

At 5,050 ft. we at length reach the final slope of Mount Hector, and now meet for the first time the gorgeous *Ranunculus insignis* in full bloom, growing on shingle-slips. A mountain-tarn is almost hidden by the tall *Danthonia*. *Helichrysum bellidioides* with very large heads and orbicular leaves, *Cotula pyrethrifolia*, and *Ourisia cæspitosa* we here collect.

At 5,200 ft. by the aneroid, at 3.45 p.m., the summit is reached. *Danthonia*, *Aciphylla Colensoi*, *Ligusticum dissectum*, *Bulbinella Hookeri*, and *Veronica Astoni* occupy the north-east face, but the south-west aspect is a steep shingle-slope with patches of *Raoulia rubra*, *Ranunculus insignis*, *Phyllachne*, and *Ligusticum dissectum*. A glorious view greets the eye from every direction. The Wairarapa Plain is spread out to the east, Kapiti Island and the Otaki beach in the west. Cape Palliser and Palliser Bay can be seen in the south, followed by the Hutt Valley—Wellington Harbour and Tupuaewainuku beyond. To the north the Tararua peaks block the view.


Flat
Camp
RIDGE
1512'
TENT
1834'
PIPIRIKI
Brass
Pukeatua Stream
WAIOTAURU
Bridge
Judd's hut
WAIOTAURU
RIV
Very bad track
WAIKANAE RIV
PUKEHINAU
flat
Camp
PUKEATUA
2655'
Camp
Very steep
Very steep
P
WAITATAPIA
2816'
Camp
Camp
OTAKI RIVER
Camp (no water)
Sub-alpine scrub
Table-top Camp
(Water)
DENNAN
4010'
4700 Appx.
HECTOR
5014'
KAPAKAPANUI
3636'
RENATA
3026'
Renata Str.
Hutt Ri
Lesser
ALPHA
4466'
OMEGA
3669'
QUOIN
3905'
Camp
PUKERUA
Blazed
MAI MOR
2793'
Str
Kerekeri Str
High
Confluence Camp
Camp
MARCHANT
3406'
Climie's main camp
Putaputa Str.
HUTT
Gorge
Forks Camp
Camp
KAKARIKI
1876'
Str
Hansen's hut
Main camp
Phillips' hut
Maungaroa Str.
KAITOKE
Main Road
Railway
0 1 2 3
Scale of Miles
N

Commencing the descent, a sharp dip of 100 ft. brings us to a valley where a chain of tarns stretches down the slope. From this point a well-defined *arête* leans to Mount Dennan.

A hill between Mounts Dennan and Hector has its vegetation cut into lanes running south-west and north-east.

Just before reaching Mount Dennan, 1,200 ft., the main ridge is broken up into several. The small valleys thus formed afford good protection to the snow grass, which flourishes exceedingly. *Astelia* beds are also intermixed with snow grass and *Aciphyllum Colensoi.* Many of these hollows, with snow grass leaves in abundance on the ground, would make an excellent camping ground. We reach our old camp at "Table Top" at 7.15 p.m., and, too tired to pitch tent, merely pull it over us, and sleep soundly through the starry subalpine night.

There is little more to tell. The next morning, the fourth since leaving Kaitoke, we dally long on "Table Top," around the camp, collecting specimens and taking notes. Here the rare *Liparophyllum Gunnii* is plentifully gathered in the habitat originally found by Mr. Petrie. It is late in the forenoon when a start is made for the Forks camp at the junction of the Waiotauru and Otaki Rivers. The descent through the bush to the river is only eventful in our passage through the subalpine scrub (*Olearia Colensoi*), and over "Dry Camp" (a ridge where all the trees have been blown down, and lie inextricably mixed)—incidents which bring home in a very human manner the feebleness of language, upon occasion, to express one's thoughts.

Avoiding all tracks leading to the right, from a fear of entering the dreaded portion of the Otaki Gorge above the Forks camp, we strike the Waiotauru rather farther to the south than we intended. Here we eat our remaining provisions as the dusk rapidly deepens into night. Although only a few more miles remain, they are among the most trying of the trip. The bush track is deeper than our boot-tops in mud, the night is dark, and a stump of candle soon burns out. It is not until 11.30 p.m. that we reach the cottage of Mr. Murray, at the Gorge Settlement, where, after being mistaken for burglars, we are hospitably sheltered for the night.

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PLANTS SEEN IN THE VALLEY OF THE PAKURATAHI.

Clematis indivisa, *Drimys axillaris*, *Cardamine hirsuta*, *Melicytus ramiflorus*, *Pittosporum tenuifolium*, *Stellaria parviflora*, *Plagianthus betulinus*, *Aristotelia racemosa*, *Elæocarpus dentatus*, *Coriaria ruscifolia* (tree tutu or tupakihi). *Pennantia corymbosa*, *Carmichaelia odorata*, *Rubus australis*, *R. schmidelioides*, *Carpodetus serratus*, *Weinmannia racemosa* (towhai), *Myrtus pedunculata*, *Metrosideros florida*, *M. hypericifolia*, *M. Colensoi*, *M. scandens*, *Epilobium junceum* var. *macrophyllum* (*E. erectum*, D.P.), *E. pubens*, *E. rotundifolium*, *E. nummularifolium*, *Fuchsia excorticata*, *Panax arboreum*, *Schefflera digitata*, *Pseudopanax crassifolium*, *Coprosma grandiflora*, *C. lucida*, *C. robusta*, *C. fœtidissima*, *C. Colensoi*, *C. microcarpa*, *Olearia Cunninghamii*, *Gnaphalium luteo-album*, *Erechtites prenanthoides*, *Brachyglottis repanda*. *Leucopogon fasciculatus*, *Myrsine salicina*, *Olea montana*, *Parsonsia capsularis*, *Muehlenbeckia australis*, *Hedycarya dentata*, *Beilschmiedia tawa*, *Knightia excelsa*, *Loranthus Colensoi*, *Urtica incisa*, *Fagus fusca*, *Podocarpus ferrugineus* (miro), *P. dacrydioides* (kahikatea), *Dacrydium cupressinum* (rimu), *Earina autumnalis*, *Gahnia setifolia*, *G. pauciflora*, *Microlæna avenacea*, *Libertia ixioides*, *Rhipogonum scandens*, *Astelia nervosa*, *Dianella intermedia*, *Freycinetia Banksii, Uncinia australis, Hymenophyllum polyanthos, H. dilatatum, H. flabellatum, H. scabrum, H. subtilissimum, H. Tunbridgense, H. multifidum, H. bivalve, Trichomanes venosum, T. reniforme, Cyathea dealbata, C. medullaris, Hemitelia Smithii, Dicksonia squarrosa, Davallia novæ-zealandiæ, Lindsaya trichomanoides, Pteris scaberula, P. incisa, Lomaria discolor, L. fluviatilis, L. membranacea, L. lanceolata, L. filiformis, Asplenium falcatum, A. bulbiferum, A. obtusatum, A. capense, A. Richardi, Nephrodium glabellum, Polypodium pennigerum, P. Billardieri, P. punctatum, P. australe, P. serpens, Gleichenia Cunninghamii, Todea hymenophylloides. Tmesipteris Forsteri.*

LIST OF PLANTS OBSERVED ON THE TARARUAS NOT IN MR. PETRIE'S LIST (Trans. N.Z. Inst., 1907, p. 299).

Flowering-plants.

Ranunculus rivularis, *Banks and Sol.*, Mount Holdsworth.
,, Munroi, *Hook. f.*, Tararuas (Buchanan).
Pittosporum eugenioides, *A. Cunn.*, Hutt Gorge.
Colobanthus Billardieri, *Fenzl.*, Mount Holdsworth.
Plagianthus betulinus, *A. Cunn.*
Aristotelia fruticosa, *Hook. f.*, Mount Holdsworth.
Coriaria angustissima, *Hook. f.*, Mount Holdsworth.
Donatia novæ-zelandiæ, *Hook. f.*, Mount Holdsworth (Townson).
Tillæa (?) debilis, *Col.*, Kaitoke Ridge.
Drosera binata, *Labill.*, Kaitoke.
Metrosideros Colensoi, *Hook. f.*, Kaitoke.
Myrtus obcordata, *Hook. f.*, Kaitoke.
,, Ralphii, *Hook. f.*, Kaitoke.
Eugenia maire, *A. Cunn.*, Otaki Gorge, Mount Hector.
Epilobium pallidiflorum, *Sol.*, Upper Hutt.
,, chloræfolium, *Haussk.*, Mount Holdsworth, Mount Hector.
,, Cockaynianum, *Petrie*, Mount Holdsworth.
Azorella nitens(?), *Petrie*, Otaki Gorge.
Aciphylla Lyallii(?), *Hook. f.*, Mount Holdsworth, Mount Hector.
Coprosma microcarpa, *Hook. f.*, Mount Holdsworth, Kaitoke.
,, Cunninghamii, *Hook. f.*
,, parviflora, *Hook. f.*, Mount Holdsworth.
,, rubra, *Petrie*, foot of Mount Holdsworth.
Lagenophora Forsteri, *D.C.*, Mount Holdsworth, Kaitoke.
Celmisia longifolia, *Cass.*, Mount Holdsworth, Mount Hector.
,, hieracifolia, *Hook. f.*, var. oblonga, Mount Alpha, 4,600 ft.
Gnaphalium luteo-album, *Linn.*
Gnaphalium Traversii, *Hook. f.*, Mount Hector.
Raoulia glabra, *Hook. f.*, Quoin.
Helichrysum Loganii, *T. Kirk*, Mount Holdsworth, Mount Hector, 4,500 ft.
,, glomeratum, *Benth. and Hook. f.*, Hutt Gorge.
,, bellidioides, *Willd.*, var. prostratum.
Craspedia uniflora, *Forst.*, Mount Holdsworth.
Erechtites prenanthoides, *D.C.*, abundant in bush clearings.
,, quadridentata, *D.C.*, ridge above Kaitoke.
,, arguta, *D.C.*
Senecio Adamsii, *Cheesem.*, Mount Holdsworth.

Wahlenbergia gracilis, *A. D.C.*, Mount Holdsworth.
Olea Cunninghamii, *Hook. f.*, Mount Holdsworth.
,, lanceolata, *Hook. f.*, Mount Holdsworth.
Gentiana Grisebachii, *Hook. f.*, Mount Hector.
Myosotis Astoni, *Cheesem.*, Mount Holdsworth, Tauherinikau Valley
Solanum aviculare, *Forst.*, Kaitoke.
Veronica catarractae, *Forst.*, var. diffusa, Mount Holdsworth.
Euphrasia zealandica, *Wettst.*
Plantago Raoulii, *Decne.*, Mount Hector.
Piper excelsum, *Forst.*, Hutt Gorge.
Muehlenbeckia australis, *Meissn.*
,, complexa, *Meissn.*
Knightia excelsa, *R. Br.*
Pimelia longifolia, *Banks and Sol.*, Mount Holdsworth.
Loranthus tetrapetalus, *Forst.*, Quoin.
Tupeia antarctica, *Cham. and Schl.*, Mount Holdsworth.
Dactylanthus Taylori, *Hook. f.*, Kaitoke.
Fagus cliffortioides, *Hook. f.*, Mount Holdsworth.
Podocarpus Hallii, *T. Kirk.*
,, spicatus, *R. Br.*
Earina autumnalis, *Hook. f.*
Orthoceras strictum, *R. Br.*, Kaitoke.
Pterostylis Banksii, *R. Br.*
,, graminea, *Hook. f.*, Kaitoke.
,, foliata, *Hook. f.*, Kaitoke.
,, trullifolia, *Hook. f.*, Kaitoke.
,, barbata, *Lindl.*, Kaitoke.
Cyrtostylis oblonga, *Hook. f.*, Kaitoke.
Chiloglottis cornuta, *Hook. f.*, Kaitoke.
Gastrodia sesamoides, *R. Br.*, Tauherinikau Valley.
Phormium tenax, *Forst.*
Juncus scheuchzerioides, *Gaud.*
,, planifolius, *R. Br.*, Mount Holdsworth.
,, caespiticius, *E. Mey.*
Luzula campestris, *D.C.*, var. picta.
Cyperus vegetus, *Willd.*
Eleocharis Cunninghamii, *Boeck.*, Kaitoke.
Scirpus cernuus, *Vahl.*, Kaitoke.
,, prolifer, *Rottb.*, Kaitoke.
,, sulcatus, *Thouars.*, Kaitoke.
Danthonia Cunninghamii, *Hook. f.*, Hutt Gorge.
,, pilosa, *R. Br.*, Kaitoke.
Arundo conspicua, *Forst.*, var. intermedia.
Agrostis Muellerii, *Benth.*
Deyeuxia Petrei, *Hack.*
,, quadriseta, *Benth.*, Mount Holdsworth.
Dichelachne crinata, *Hook. f.*, Kaitoke.
Poa seticulmis, *Petrie.*

Filices.

Hymenophyllum multifidum, *Swartz.*
,, polyanthos, *Swartz.*
,, bivalve, *Swartz.*

Hymenophyllum flabellatum, *Lab.*
,, subtilissimum, *Kunze.*
,, dilatatum, *Swartz.*
,, Tunbridgense, *Smith.*
,, scabrum, *A. Rich.*
,, demissum, *Swartz.*
,, rarum, *R. Br.*
Trichomanes venosum, *R. Br.*
,, reniforme, *Forst.*
,, strictum, *Menz.*, Mount Dennan.
Cyathea dealbata, *Swartz.*
,, medullaris, *Swartz.*
Hemitelia Smithii, *Hook.*
Alsophila Colensoi, *Hook. f.*, Mount Holdsworth.
Dicksonia squarrosa, *Swartz.*
Davallia novæ-zealandiæ, *Col.*
Lindsaya trichomanoides, *Dryand.*
Adiantum affine, *Willd.*
Hypolepsis millefolium, *Hook.*
,, distans, *Hook.*
Pteris incisa, *Thunb.*
,, scaberula, *A. Rich.*
,, aquilina, *Linn.*
Lomaria lanceolata, *Spreng.*
,, membranacea, *Col.*
,, fluviatilis, *Spreng.*
,, filiformis, *A. Cunn.*
,, discolor, *Willd.*
,, capensis, *Willd.*, var. minor.
,, Patersoni, *Spreng.*
,, alpina, *Spreng.*
,, vulcanica, *Blume.*
Asplenium falcatum, *Lam.*
,, obtusatum, *Forst.*
,, flaccidum, *Forst.*
,, Hookerianum, *Col.*
,, fluviatilis, *Spreng.*
,, lucidum, *Forst.*
Aspidium Richardi, *Hook.*
,, capense, *Willd.*
,, aculeatum, var. vestitum.
Nephrodium glabellum, *A. Cunn.*
Polypodium pennigerum, *Forst.*
,, Billardieri, *R. Br.*
,, punctatum, *Thunb.*
,, australe, *Mett.*
,, serpens, *Forst.*
,, grammitidis, *R. Br.*
Gleichenia Cunninghamii, *Heward.*
Todea hymenophylloides, *A. Rich.*
,, superba, *Col.*
Lycopodium scariosum volubile, *Forst.*
Tmesipteris tannensis, *Benth.*

ART. IV.—*Unrecorded Habitats for New Zealand Plants.*

By BERNARD CRACROFT ASTON, F.I.C., F.C.S.

[*Read before the Wellington Philosophical Society, 1st September,* 1909

Ranunculus sericophyllus, *Hook. f.*
Bold Peak, Kinloch, Wakatipu.

Lepidium oleraceum, *Forst.*
Snares; Antipodes Island; Titahi Bay; Ohau Bay, near Wellington.

Lepidium tenuicaule, *T. Kirk*, var. minor.
Titahi Bay, Wellington.

Hymenanthera obovata, *T. Kirk.*, var.
Titahi Bay, Wellington.
This Mr. Cheeseman considers is an intermediate form between *H. crassifolia* and *H. obovata.*

Claytonia australasica, *Hook. f.*
Enderby Island, Auckland Islands.

Aristotelia Colensoi, *Hook. f.*
Colac Bay, Southland.

Carmichaelia grandiflora, *Hook. f.*
Bold Peak, Kinloch, Lake Wakatipu.

Tillæa multicaulis, *Petrie.*
Bluff Hill, Southland.

Tillæa debilis, *Col.*
Happy Valley Beach, Wellington.

Gunnera dentata, *T. Kirk.*
Lowther, near Lumsden.

Gunnera arenaria, *Cheesem.*
Fortrose, Southland.

Fuchsia excorticata, *Linn. f.*
Head of Laurie Harbour, Auckland Island.

Aciphylla Traillii, *T. Kirk.*
Top of Rock and Pillar Range.

Apium prostratum, *Labill.*
Antipodes Island.

Aciphylla, sp.
Mount Holdsworth; Quoin; Mount Hector.

Panax anomalum, var. microphyllum.
Sandymount, Otago.

Pseudopanax ferox, *T. Kirk.*
Green Island; Taieri Gorge; Gore; Clifden.

Coprosma microcarpa, *Hook. f.*
Tararua Mountains, Day's Bay, Wellington.

Coprosma Buchanani, *T. Kirk.*
Fruit translucent, white, globose. Happy Valley beach, Wellington.

Coprosma virescens, *Petrie.*
Clifden (Waiau River).

Coprosma rubra, *Petrie.*
Clifden; Tapanui; Mount Holdsworth.

Craspedia uniflora, *Forst.*
Mount Dumas, Campbell Island.

Helichrysum bellidioides, *Willd.*, var. prostratum.
Mount Hector, 5,000 ft.

Celmisia hieracifolia, *Hook. f.*, var. oblonga.
Mount Alpha (Tararuas), 1,600 ft.

Senecio Greyii, *Hook. f.*
Little Mukumuku cliffs, Palliser Bay.

Taraxacum officinale, *Wigg.*
Indigenous form, Campbell Island.

Cyathodes pumila, *Hook. f.*
Blue Mountains, Otago, 3,000 ft.

Cyathodes Colensoi, *Hook. f.*
Common under bog pines, Blue Mountains, Otago, 3,000 ft.: Quoin, (Tararuas), 3,900 ft.

Samolus repens, *Pers.*
Eweburn, Maniototo Plain.

Myosotis Astoni, *Cheesem.*
Mount Holdsworth.

Calceolaria repens, *Hook. f.*
Maungatiriri River; Hutt Gorge.

Mazus radicans, *Cheesem.*
Bluff, Southland.

Veronica odora, *Hook. f.*
Port Ross, Enderby Island; Norman Inlet, Enderby Island.

Euphrasia zealandica, *Wettst.*
Mount Hector.

Ourisia sessilifolia, *Hook. f.*
Takitimos, 4,000 ft.

Teucridium parviflorum, *Hook. f.*
North Otago Heads; Clifden.

Muehlenbeckia, nov. sp.
Wainui-o-mata mouth, Orongorongo, Wellington.

Peperomia Endlicheri, *Miq.*
Titahi Bay; Evans Bay, near Wellington.

Pimelia sericeo-villosa, *Hook. f.*
Ben Lomond, Lake Wakatipu, 4,000 ft.

Paratrophis Banksii, *Cheesem.*
Wainui-o-mata mouth.

Corysanthes oblonga, *Hook. f.*
Port Ross, Auckland Island.

Corysanthes rivularis, *Hook. f.*
Norman's Inlet, Laurie Harbour, Auckland Island.

Thelymitra, nov. sp.
Bluff Hill, Southland.

Thelymitra pachyphylla, *Cheesem.*
Bluff Hill, Southland.

Pterostylis foliata, *Hook. f.*
Kaitoke.

Pterostylis barbata, *Lindl.*
Kaitoke.

Adenochilus gracilis, *Hook. f.*
Under *Fagus* at 1,000 ft. on Maungatua, Otago. (This habitat was attributed to Mr. Petrie in the "Manual.")

Gastrodia sesamoides, *R. Br.*
Tauherinikau Valley.

Uncinia, sp.
Port Ross, Auckland Island.

Paspalum Digitaria, *Poir.*
Sydney Street, Wellington.

Microlæna avenacea, *Hook. f.*
Auckland Island.

Poa incrassata, *Petrie.*
Flowers January, Campbell Island.

Poa Tennantia, *Petrie.*
Snares Island.

Poa Astoni, *Petrie.*
Snares Island.

Poa antipoda, *Petrie.*
Port Ross, Auckland Island.

Poa aucklandica, *Petrie.*
Summit of hill above Camp Cove boat depot, Carnley Harbour, Auckland Island.

Poa oraria, *Petrie.*
Snug Cove, Doubtful Sound. (A new tussock-grass.)

Deschampsia gracillima, *T. Kirk.*
Port Ross, Auckland Island.

Deschampsia Chapmanii, *Petrie.*
Port Ross, Auckland Island.

Atropis antipoda, *Petrie.*
Antipodes Island.

Atropis stricta, *Hack.*
Enderby Island; Auckland Island.

Deyeuxia Forsteri, var. Lyallii, *Kunth.*
Enderby Island; Auckland Island.

Deyeuxia setifolia, *Hook. f.*
Port Ross, Auckland Island.

Asperella lævis, *Petrie.*
Snug Cove, Doubtful Sound.

Art. V.—*Some Additions to the* Perlidæ, Neuroptera-Planipennia, *and* Trichoptera *of New Zealand.*

By E. J. Hare.

Communicated by G. V. Hudson, F.E.S.

[*Read before the Wellington Philosophical Society, 1st September, 1909.*]

The descriptions that follow are made from specimens kindly sent to me by Mr. G. V. Hudson, F.E.S., of Wellington, New Zealand.

PERLIDÆ.

Four new species are described below. Of these, probably two have been included hitherto, with a Tasmanian species, under the name of *Leptoperla opposita*, Wlk., and I have merely put into practice the opinion of McLachlan in separating them. No more revolutionary is the foundation of a new genus for the *Chloroperla cyrene* of Newman.

The number of species at present recognised in New Zealand is six.

Genus Leptoperla, Newm.

Leptoperla fulvescens, n. sp.

♀. Reddish-brown. Antennæ rather longer than forewings; 1st joint stoutly cylindrical, 2nd oval; brownish-ochreous. Meso- and metathorax fuscous-brown; abdomen reddish, dark fuscous at extremity. Forewings greyish-ochreous, veins fulvous; discal area, and spaces surrounding veinlets of posterior half, pale, subhyaline. Hindwings subhyaline, iridescent, costa tinged with reddish-ochreous; neuration with an asymmetrical tendency. Legs reddish-brown. Caudal setæ reddish-ochreous, the under-surface of the proximal joints with a fringe of yellow hairs.

Length of body, 13 mm. Expanse of wings, 25 mm.

Hab. Karori, Wellington.

Leptoperla maculata, n. sp.

Blackish-fuscous. Antennæ nearly as long as forewings, fuscous; 1st joint stoutly cylindrical, 2nd rounded. Forewings shaded with grey, veins dark brown; posterior veinlets surrounded by grey oval spots. Hindwings greyish, subhyaline. Legs dark fuscous, mixed, on posterior femora and tibiæ, with pale dull yellow. Caudal setæ slender, light fuscous, as long as abdomen. In the male the appendices are light brown and rather slender.

Length, 10–12 mm. Expanse of wings, 22–27 mm.

Hab.- New Zealand.

Leptoperla confusa, n. sp.

Differs from *L. maculata* as follows: Smaller and rather paler. Forewings: 1st sector terminally furcate; posterior veinlets arranged in distinct series, the grey markings about the veinlets of each series being confluent and not in the form of distinct spots. Hindwings: Veins 7 and 9 furcate. Legs reddish brown, almost unicolorous.

Length, 8 mm. Expanse of wings 19 mm.

Hab. New Zealand.

Leptoperla hudsoni, n. sp.

♂. Fuscous. Antennæ shorter than forewings, dark fuscous. Head and thorax blackish fuscous; abdomen rather paler. Forewings greyish-fuscous; posterior veinlets very distinct, outlined with dark fuscous: 1st sector terminally furcate. Hindwings greyish-fuscous. Legs reddish-brown; tibiæ paler and rather slender. Caudal setæ slender, as long as abdomen, fuscous.

Length, 8 mm. Expanse of wings, 17 mm.

Hab. Karori, Wellington.

The New Zealand species of *Leptoperla* may readily be identified by the following artificial key:

1.	First sector of forewings terminally furcate	2
	First sector of forewings simple	3
2.	Posterior veinlets of forewings surrounded by grey spots..	*L. confusa.*
	Posterior veinlets of forewings merely outlined	*L. hudsoni.*
3.	Reddish-brown	*L. fulvescens.*
	Blackish-fuscous	*L. maculata.*

The characters afforded by the neuration seem to separate the genus into two natural divisions, but such a schism is inadvisable in practice in the present state of our knowledge.

The Tasmanian species (*L. opposita*, Wlk.) has the posterior veinlets of the forewings very numerous and distinct, and not surrounded by spots; and while the posterior femora have a distinct paler band, the knees are dark fuscous. It is also a larger insect than either *L. confusa* or *L. maculata.*

Genus HETEROPERLA, gen. nov.

Antennæ strong, 1st joint large and cylindrical, 2nd practically uniform with its successors. Labial palpi very short; 1st and 2nd joints minute; 3rd and 4th equal, ovate; 5th very small and rounded. Prothorax subquadrate, rather broader than head. Forewings: Upper branch of 1st sector and lower branch of 2nd sector furcate, cubital furcate at $\frac{1}{4}$, the posterior half of the forewings with 7 parallel veins; subcostal veinlets numerous. Hindwings broad, subtriangular; 1st cubital vein furcate, others simple. Caudal setæ short, incurved.

Distribution: New Zealand.

Type, *Heteroperla cyrene* (*Chloroperla cyrene*, Newm.; *Perla* (?) *cyrene*, Wlk. et McL.; *Stenoperla* (?) *cyrene*, Hutton).

This genus would, no doubt, have been created long ago but for the fact that there were no specimens available which were sufficiently well preserved for detailed examination. It seems to have no affinities with any other existing genus of *Perlidæ*, except perhaps with *Stenoperla*, McL., with which, however, it is only very remotely connected.

NEUROPTERA-PLANIPENNIA.

Genus DREPANEPTERYX, Leach.

Drepanepteryx maori, n. sp.

♀. Brownish-fuscous. Antennæ brown. Forewings subhyaline, anterior half partly, and posterior half wholly, suffused with brown; six sectors, the 4th and 5th connected, the 6th connected with cubitus; ten gradate veinlets in inner series, thirteen in outer, each series marked by a dark-brown line angulated near costa; a dark-brown spot on upper branch of superior cubitus before 1st gradate series; termen not very deeply excised, with two white marginal spaces. Hindwings iridescent; costa brownish-fuscous, darker on pterostigma; outer gradate series and an irregular dorsal spot fuscous. Legs pale brownish-ochreous.

Length of body, 6 mm. Expanse of wings, 16 mm.

Hab. Wainuiomata River, Wellington.

The nearest relation of this species appears to be the Australian *D. binoculus*, McL.

Drepanepteryx humilior, n. sp.

Light brownish-fuscous. Antennæ ochreous, ringed with brown. Forewings with apical margin only slightly excised; subhyaline, faintly clouded with greyish-brown; nine gradate veinlets in inner, thirteen in outer, series; veins marked with brown; numerous brown spots irregularly distributed, with a large brown spot on upper branch of superior cubitus before 1st gradate series. Hindwings hyaline, iridescent; subcosta shaded with fuscous, paler on pterostigma; a fuscous line along outer gradate series, and a light-fuscous dorsal suffusion. Legs pale ochreous. Abdomen ochreous beneath.

Length of body, 5 mm. Expanse of wings, 13 mm.

Hab.—Wainuiomata River, Wellington.

Quite distinct from the Queensland *D. humilis*, McL., which, in all probability, has never occurred in New Zealand, and should therefore be excluded from New Zealand lists.

TRICHOPTERA.

Genus HELICOPSYCHE, Hagen.

Helicopsyche zealandica, Hudson, n. sp.

Fuscous-brown. Antennæ slightly shorter than forewings, clothed with pubescence; 1st joint with longish hairs. Maxillary palpi stout, terminal joint curved, ascending; densely hairy. Wings with dense clothing of hairs: forewings with costa and dorsum nearly parallel; lower branch of sector and upper branch of superior cubitus closely approximated; greyish, with light-fuscous hairs mixed with golden, somewhat darker on longitudinal veins; termen and fringe mixed with black: hindwings rather narrow, with light-fuscous hairs; dorsal fringe very long, greyish-fuscous. Legs light brownish-fuscous, posterior tibiæ darker; spurs 2, 4, 4, the inner longer than the outer, and the median pair of posterior tibiæ close to terminal pair; tarsal joints pale-tipped.

Length of body, 5 mm. Expanse of wings, 12 mm.

Hab.—Wellington.

The species is structurally described here for the first time. I have adopted the name suggested by Mr. Hudson.

Genus PHILORHEITHRUS, gen. nov.

[Greek, *ῥεῖθρον* = stream.]

1st joint of antennæ longer than breadth of vertex, densely hairy. Maxillary palpi with basal joint very short, 2-5 subequal. Labial palpi with 1st joint short, the 3rd longer than the 2nd. Forewings rather narrow, dilated before apex; subcosta and radius connected near base: a series of transverse veins connecting the longitudinal veins successively from radius to upper branch of superior cubitus closes a large discal area: a chitinous nodule on dorsum near base serves as frenulum. Hindwings obtusely elongate-triangular, with a closed discal area similar to that of forewings. Tibial spurs 2, 4, 4.

Distribution: New Zealand.

The type (*P. agilis*, Huds.) is described by Hudson ("New Zealand Neuroptera," p. 64) as follows:

"? *agilis*, n. sp.

"The expansion of the wings is about 1¼ inches. The antennæ are rather stout, and about the same length as the forewings. Spurs 2, 4, 4. The forewings have the costa slightly arched at the base, and much arched before the apex; the termen is sharply excavated near the middle. The general colour of the forewings is pale brown, paler in the middle with a large almost white patch towards the tornus, partially bordered by a number of dark chocolate-brown markings. The hindwings are yellowish-brown, darker towards the apex. The body is dark brown."

In the same place is a description of the larva and of the remarkable habits of the imago.

Hab.—Wainuiomata River, Wellington.

Genus HYDROPSYCHE, Pict.

Hydropsyche auricoma, n. sp.

Brownish-fuscous. Antennæ brownish-fuscous, segments tipped with pale ochreous. Head, prothorax, and mesothorax densely clothed with pale-golden hairs. Forewings greyish-yellow, with darker reticulations; four series of brownish-fuscous marks tending to form transverse bands. Hindwings greyish, slightly iridescent. Legs pale ochreous. Abdomen brownish-ochreous, darker above.

Length of body, 5 mm. Expanse of wings, 15 mm.

Hab.—Wellington.

Genus HYDROBIOSIS, McL.

Hydrobiosis occulta, n. sp.

♂. Dark brown. Antennæ rather longer than forewings, dark brown, almost unicolorous; the basal joint, with the face and prothorax, clothed with golden-brown hairs. Forewings dark brown with dense golden-brown pubescence. Hindwings with pubescence scantier and dark brown. Legs light ochreous-brown. Abdomen without ventral tooth. Penis yellow; inferior appendices directed upwards and curved so as to meet over extremity of abdomen.

Length, 6 mm. Expanse of wings, 14 mm.

♀. Differs from ♂ as follows: Antennæ not longer than forewings; pubescence of forewings almost wholly dark brown.

Length, 6 mm. Expanse of wings, 17 mm.

Hab.—Wainuiomata River, Wellington.

Hydrobiosis ingenua, n. sp.

Brownish-fuscous. Antennæ as long as forewings, brown. Maxillary palpi pilose, fuscous. Ocelli dark brown, distinct. Head, prothorax, and mesothorax densely clothed with brown hairs. Forewings brownish-fuscous, hairs lighter; a pale-golden band before termen and a tuft of black hairs on superior cubitus at ⅓. Hindwings greyish-fuscous, strongly iridescent. Legs greyish-ochreous, tibiæ and tarsi marked with fuscous, spurs brownish-ochreous.

Length of body, 6 mm. Expanse of wings, 14 mm.

Hab.—Wainuiomata River, Wellington.

ART. VI.—*Notes on some Rocks from Parapara, Bluff Hill, and Waikawa.*

By J. ALLAN THOMSON, B.A., B.Sc., F.G.S., A.O.S.M.

Communicated by G. M. Thomson, F.L.S.

[*Read before the Otago Institute, 14th September, 1909.*]

INTRODUCTION.

THE description of a few isolated rocks can seldom advance geological knowledge very greatly, and this paper must be regarded mainly as an attempt to draw attention to some interesting regions of the Dominion. The day has gone by when descriptions of new types of igneous rocks can attract more than local interest, and petrologists are more and more tending to use description only as a handle for the discussion of theoretical questions. The two outstanding subjects of discussion are,—

(1.) The nature of igneous magmas, the history of their consolidation and their relations to neighbouring rocks, involving the theories of differentiation, admixture of igneous magmas, and assimilation of the walls of the magma-basins.

(2.) The mode of formation of the crystalline schists.

New Zealand is a country so rich in rock-types, and so well provided with natural sections, that it is not vain to suppose that much material may be found which may throw important light on these philosophical questions. Two such districts are outlined in the sequel.

PART I.—PARAPARA, NELSON.

The authors of Bulletin No. 3 of the Geological Survey describe certain basic facies of the Waitapu granite as occurring only at the contact with the carbonate rocks, and are led to the conclusion that it was owing to the introduction of the carbonate bases into the acid magma that these basic facies arose. This theory of assimilation or absorption has its home in France, and its most notable protagonists in Levy* and Lacroix.† It receives support from Finnish geologists, but is strongly opposed by the differentiation school of Rosenbusch and Brögger, with whom English petrologists are in large part inclined to agree. In America, however, the French have a strong following.‡

One of the difficulties in settling the question is the rugged and inaccessible nature of the country in Ariège described by Lacroix, while another lies in the complication of phenomena in regions of crystalline schists such as Adams describes. It suggested itself to me that the Parapara district would furnish an excellent case on which to test the rival theories, and Dr. Bell, Director of the Geological Survey, kindly furnished me with six specimens for preliminary study. These will now be described in detail.

The members of the igneous complex are represented by an acid and a basic type. The acid rock has the structure of an augen-gneiss and the mineral composition of a binary granite. The feldspars, which form the augen, are mostly untwinned and partially sericitised, and are referred to orthoclase, but there are also present microcline, and albite in microcline microperthite. Graphic intergrowths of quartz and orthoclase are fairly abundant. Both dark and white mica are arranged in parallel flakes along the planes of foliation, the former in course of alteration to chlorite and rutile. Apatite is not abundant, but magnetite is more plentiful, and it is evident that the original iron-ore was titaniferous, since the magnetite shows minute outgrowths of a highly refringent platy mineral determined as anatase. There is, in addition, a brown mineral of which only one large prismatic crystal appears in the section, with a pleochroism from brown to yellow. The orientation is not favourable for study in convergent light, and the mineral is doubtfully referred to cero-epidote on account of its low obliquity of extinction. Although it is paler in colour than is usual in common orthite, it is too pleochroic for monazite.

The basic rock shows, in section, abundant common hornblende enveloping colourless patches, which are evidently pseudomorphs after feldspar. They consist chiefly of muscovite and epidote, but a little basic plagioclase has here and there escaped alteration. Magnetite is probably an original constituent, but much of the iron is now present as pyrite.

Secondary alterations in the large hornblende plates are of two kinds: there is a decomposition to clinochlore and sphene, to be ascribed to shallow-seated alteration, and also a local separation of minute needles of rutile and linearly arranged granules of magnetite, giving rise to a rude schiller-like striation oblique to the prismatic cleavages. This latter alteration is very common in the hornblende of rocks that have suffered shearing, and seems to be due to an attempt on the part of magmatically formed brown hornblende, rich in iron and titanium, to adapt itself to the altered conditions according to the volume law. From the presence of these striations and the strongly green colour of the hornblende, it appears original, and not a uralitic pseudomorph of pyroxene, and the rock is therefore an altered hornblende dolerite or gabbro.

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* Levy, MM. "Le granite de Flamandville, &c.," Bull. Carte geol. Fr., tome v, No. 36, 1893–4. "Sur l'évolution des magmas de certains granites à amphibole," Comptes Rendus, cxxi, p. 228, 1895. "Sur quelques particularités de gisement du porphyre bleu de l'Esterel," Bull. Soc. geol. Fr., 3rd ser., xxiv, p. 123, 1896.

† Lacroix, A. "Les granites des Pyrenées et leur phénomènes de contact." Bull. Carte geol. Fr., tome x, No. 64. 1898–99.

‡ *Cf.* Adams, F. D., on the Structure and Relations of the Laurentian System in Eastern Canada. Q.J.G.S., lxiv, pp. 127–47. 1908.

The other four rocks come from the contact aureole of the granite, one being an amphibolite intercalated among the stratified rocks. It is almost completely recrystallized, and in description it is desirable to make use of the terms introduced by Becke.* These are based on the belief that in crystalline schists the formation of the different minerals has proceeded simultaneously, since each may be found enclosed in the others, in opposition to the sequence of growth amongst minerals of igneous rocks. Owing, however, to the different powers of crystal-growth exhibited by the minerals, they differ widely in their development of crystal-faces, so that some appear moulded on others. The resulting structure is called "krystalloblastisch," or, *anglicé*, "crystalloblastic," and the apparent order of separation is termed "the crystalloblastic order." Well-shaped (euhedral) crystals are termed "idioblastic," those with irregular boundaries (anhedral) "xenoblastic," and other structural terms used in the descriptions of igneous rocks are similarly adapted with the suffix "blastic." In this amphibolite there are evidences of former igneous structure in the presence of original phenocrysts of feldspar. The rock is therefore "porphyro-blastic." The minerals, especially the sphene, are frequently honeycombed with inclusions, and the crystalloblastic order appears to differ from that established by Becke, in that feldspar is idioblastic to sphene and hornblende; but this apparent difference may be due to the incomplete recrystallization of the feldspar. These three minerals are the most abundant constituents of the rock, but epidote, apatite, and pyrite are also present, and secondary sericite is forming in the feldspar, which is near andesine in composition. The mineralogical composition of the rock shows that it is an ortho-amphibolite, the large crystals of plagioclase that it was porphyritic, but to arrive at the nature of the original rock an analysis would be necessary.

The three stratified rocks are interesting as containing contact minerals, a class which must be common but has not yet been widely observed in New Zealand. One rock is a biotite-hornfels, containing biotite, quartz, plagioclase, feldspar, chlorite, and magnetite. The quartz forms a fine mosaic of polygonal grains, between the interstices of which are inserted abundant flakes of biotite, locally decomposed to chlorite.

The other two rocks are marbles with contact minerals. In one—the "complex-carbonate rock" of the Survey—there is little besides the large polygonal carbonate grains. White mica and sphene can be recognised, but small needles of a highly refringent and bi-refringent mineral lying in the carbonate defy determination in section, although they can scarcely be other than rutile. The other must have been an impure dolomitic rock, for, besides calcite, a colourless augite occurs very abundantly both in separate grains and in small aggregates. Octagonal cross-sections may occasionally be seen, but most of the crystals are rounded or irregular in shape, and are interrupted in crystallization by inclusions, so that the form is like a sponge. Sphene and quartz are found in the pores of the sponge, and also independently in the calcite. Finally there is a little pyrites.

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* Becke, F. Ueber Mineralbestand und Struktur der krystallinischen Schiefer." Comptes Rendus ix Sess. Cong. Geol. Inter. Vienna, 1904, pp. 553–70.

This collection of rocks, interesting as it is in itself, throws little light on the question of assimilation. Certainly there are many points of resemblance with the Pyrenean granite-contacts, but the endomorphic modifications of the granite are too poorly represented to draw a parallel. A complete investigation would involve the detailed mapping of these basic facies with the rocks at their contact. Even then, the phenomena would admit of either interpretation, unless a thorough chemical examination of both classes of rocks conclusively proved the absorption of the earthy bases. Probably the truth will be found to lie between the extreme positions, a partial assimilation accompanying laccolitic differentiation. This paper will serve its purpose if it draws attention to this interesting question.

PART II.—BLUFF HILL.

The rocks here described are the result of a few hours' collection along the shore south and west from Bluff Harbour. Immediately joining the harbour is a series of apparently bedded rocks, which are in some cases so dense as to resemble hornstones, but in other cases suggest sheared porphyritic igneous rocks. A section of one of the denser varieties proves the rock to be a fine-grained banded hornblende schist. Some of the bands are richer in hornblende, others in epidote and iron-ores, while a mosaic of polygonal quartz grains is common to both. Apatite is not rare, and rutile is very abundant in minute prismatic crystals with pyramidal terminations projecting out of quadrate magnetite crystals. A similar mineral occurs in more rounded crystals in the quartz, and is difficult to determine with certainty as rutile or sphene, but there are a few undoubted larger crystals of the latter. The hornblende, a common green variety, occurs in prismatic crystals mostly parallel to one another, more rarely oblique to the schistosity. Sometimes the crystals are so slim and needle-like as to simulate sillimanite needles. Cross-sections show that in addition to the prismatic faces the B pinacoids (010) are present, a feature rarely observed in hornblende schists. The epidote does not show clear crystalline form, but occurs in granular aggregates elongated in the same direction as the hornblende. The crystalloblastic order appears to be apatite, magnetite, rutile, sphene, hornblende, epidote, and finally quartz.

A vein of coarser grain separates the hornblendic and epidotic bands, and contains, besides hornblende, epidote, and quartz, a few large twinned basic feldspars. The absence of albite in the rock is surprising if it is derived from an igneous or pyroclastic rock. Untwinned feldspar is always difficult to recognise in the presence of quartz, but an examination of as many of the colourless grains as possible in convergent light gave only uniaxial figures. From the absence or relative paucity of feldspar the rock has more affinities with a para-hornblende-schist than with an ortho-hornblende-schist. It presents many points of resemblance to the "green schists" among the Old Lizard Head series of Cornwall.

A dyke of a dark porphyritic rock crosses the schist formation at an angle approaching 45°. In section this rock also proves to be quite schistose, but, unfortunately, the directions of schistosity of the dyke and the intruded schists were not compared in the field. The phenocrysts consist of large compact hornblende crystals, often white in the centre, and smaller anhedral feldspars. In section the hornblende presents rhomboidal shapes with ragged outlines, and is seen to be a strongly pleochroic variety of common hornblende, with occasional tremolitic cores. Not seldom some crystallographically discontinuous hornblende crosses the main phenocryst, a feature often observed in uralite. The feldspars give more rounded outlines, and are turbid, and filled with calcite. They include also hornblende, magnetite, and epidote. The groundmass consists of elongated, often needle-like hornblende prisms, with associated biotite flakes, slightly elongate feldspars, probably albite, showing Carlsbad twinning, magnetite grains, and occasionally a green epidote. The rock is thus a porphyroblastic hornblende-schist derived from a basic igneous dyke-rock.

The next three specimens to be described come from a small headland about half a mile round the coast to the south-west, just beyond the mouth of the harbour. There is here an interesting complex of coarse holocrystalline rocks. Three elements may be distinguished, a dark dioritic rock (No. 1), which appears to vein a much lighter dioritic rock (No. 2), occasionally enclosing both the latter and a coarse hornblendic rock (No. 3) as xenoliths. The dark diorite (No. 1) is often gneissose, while the walls of light diorite (No. 2) which surround it are quite massive.

In section, all three rocks present a similar assemblage of minerals, but the relative amounts of iron-ores, hornblende, and feldspar vary very considerably. Hornblende forms the predominate mineral of No. 3, and is a brown-green variety with a fine schiller-structure in the centre, surrounded by a margin of green hornblende. Besides the hornblende, there is a limited amount of a basic feldspar and iron-ores. The hornblende shows a fair approach to idiomorphism, but the larger iron-ores, probably ilmenite, are moulded both on hornblende and feldspars. Minute octohedra of magnetite are abundantly included in the two last-named minerals, but are probably of secondary formation.

In No. 1, iron-ores and hornblende of the same nature as above described are abundant, but feldspar predominates, and besides these minerals a little apatite and pyrite are found. A very peculiar zoning is observable in the feldspar; there are only two zones, separated by a boundary of the most irregular nature. The cores are in some instances as basic as labradorite, but the exteriors are so acid that there is a marked difference of relief between the two on lowering the condenser of the microscope, and the Becke effect may be easily observed. The Carlsbad and albite twinning of the cores does not persist in the exteriors, as in the case of albitization recently described by Bailey and Grabham* in the quartz dolerites of the central valley of Scotland, but it appears probable that something of similar nature has taken place here.

The structure differs from that of No. 3 in that the hornblende is distinctly ophitic to the feldspar. This observation is in accord with recent theories of the dependence of structure on eutectic relations,† since in the former rock the hornblende is in excess, and in the latter the feldspar predominates. But caution must be used in describing rocks as much altered as these, for, though in No. 2 the hornblende is moulded on the feldspar, it is also included within it, a structure already noted typical of the crystalline schists. There is also evidence for a slight cataclasis in the section.

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* Bailey, E. B., and Grabham, G. W. "Albitization of Basic Plagioclase Feldspars." Geol. Mag. Dec. V, vol. vi, p. 250. 1909.

† Vogt, J. H. L. "Physikalische-chemische Gesetze der Kristallisationfolge in Eruptiogesteine." Tsch. min. u. petr., Mitt. xxiv, p. 437. 1905.

A still paler variety of hornblende may occasionally be seen in this rock, occurring in almost colourless fibrous forms with beautiful polysynthetic twins. Further study would be necessary to prove whether this is due to bleaching, to recrystallization of coloured hornblende with separation of iron-oxides, or to uralisation of previously existing pyroxenes.

In No. 2 the feldspars predominate greatly over the darker minerals. They give evidence of considerable crushing in strain shadows, bent twin lamellæ, and local cataclasis. Often irregularly disposed grains are included in the larger crystals. Both coarse and fine albite lamellation may be observed, while pericline twinning is rare. Probably more than one variety of feldspar is present, and, indeed, the larger crystals show gradual zoning from the centre to periphery, but the prevailing species appears to be andesine. Delicate colourless needles are often abundant in the feldspars, and seem to be sillimanite. Beyond these the feldspars show little sign of alteration with the exception of rare grains of epidote or zoisite, and flakes of chlorite which have probably migrated from the ferromagnesian minerals along cracks. The hornblende and iron-ores occur in small patches of individuals with such ragged contours that the structural relations to the feldspars cannot be made out. The cores of the hornblende crystals generally consist of a paler variety in optical continuity with the green exteriors, so that the former presence of pyroxene is suggested. This small collection of rocks is yet sufficient to show that there is a considerable diversity of rocks in Bluff Hill. It would be exceedingly valuable to have a detailed examination of this area made, as the phenomena observed are probably common to a large part of Stewart Island, if not also in the Sounds region, and Bluff Hill is a much more easily accessible region. The relative ages of the different rocks, the mode of origin of the foliation, whether arising during or after consolidation, the origin of the rock-variations and "basic secretions," whether by pure differentiation or differentiation combined with absorption as in Skye, are a few of the problems presented for solution. Probably many analogies will be found with the Lizard district of Cornwall, on which the Geological Survey of Great Britain is shortly issuing a detailed memoir.

PART III.—WAIKAWA.

The last rock is an isolated beach-pebble picked up at Waikawa, and possesses interest as being a type not hitherto recorded in New Zealand. The other beach-pebbles consist mainly of microgranites derived from the Triassic conglomerates, but from its soft nature it is more probable that this rock has come from a neighbouring intrusion. It shows a rich mineralogical association, consisting of amphiboles, biotite, muscovite, clinozoisite, epidote, two varieties of chlorite, talc, magnetite, and pyrite, but hornblende is so abundant as to render the designation "lustre-mottled hornblende rock" applicable.

The hornblende occurs chiefly in large pœcilitic plates of a pale-brown variety, passing gradually to a pale-green on the exteriors. The minerals enclosed pœcilitically are feldspar and secondary minerals, partly after feldspar and partly after some ferromagnesian, while there are chloritic areas with sphene, which may simply represent alterations of a hornblende.

The feldspars are often rounded, and show good albite twinning with rarer pericline lamellæ. The extinction angles are characteristic of basic labradorite. Of the secondary minerals the chief is tremolite, oriented in crystallographic continuity with its host. This structure, described by me* in the amphibolite of Glendalough, Ireland, is commonly ascribed to the uralitisation of pyroxene, but may also arise, as shown at Glendalough, from the amphibolitisation of olivine. Probably both methods have operated here. Occasionally small fibres of tremolite oriented independently of the host occur in these areas. The feldspar inclusions are sometimes wholly or partly replaced by clinozoisite associated with muscovite and a feebly birefringent chlorite. The green margins of the hornblende plates contain similar inclusions, and, in one case, twinned clinochlore and small prisms of pale actinolite.

Only one large crystal of biotite is seen in the section, and it includes hornblende.

Outside the large poecilitic plates, feldspars altering to clinozoisite and muscovite are not rare, but there is a large development of recrystallized actinolitic hornblende fibres pointing in all directions, but most often distinctly aggregated in bundles, and interspaced with most of the secondary minerals included in the large plates. There are, in addition, some areas consisting of finely divided talc, into which fibres of hornblende project. It is difficult to be sure of talc in the presence of sericitic muscovite, since there is no certain microscopic method of discriminating between these minerals, unless recourse be had to microchemical tests; but the mineralogical association supports the general appearance. These areas do not contain clinozoisite or epidote, which are associated with muscovite in the altered feldspars, and contain hornblende, which does not occur in the latter. Assuming the presence of talc, these areas are then pilite† after olivine, and the rock is derived from a hornblende olivine dolerite such as Harker‡ describes from Anglesey in association with hornblende-peridotites.

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[*] Thomson, J. A. "The Hornblendic Rocks of Glendalough and Greystones." Q.J.G.S., lxiv, p. 475. 1908.

[†] Becke, F. "Eruptiogesteine aus der Gneissformation des niederösterreichischen Waldviertels." Tsch. min. u. petr., Mitt. v, p. 147. 1883.

[‡] Harker, A. "The Bala Igneous Rocks of Carnarvonshire," pp. 92, 97.

ART. VII.—*On some Armour presented to Titore, a Nga Puhi Chief, by H.M. William IV in* 1835.

By A. HAMILTON.

[*Read before the Wellington Philosophical Society, 6th October*, 1909.]

DR. MAUI POMARE deposited in the Dominion Museum in November, 1908, some pieces of "armour" which was supposed to be the armour belonging to the great Nga Puhi chief Hongi.

Dr. Pomare stated that Hongi's armour descended to his relative and fighting chief, Tuwhare. About the end of the twenties this chief led an expedition against the Whanganui Tribe, and, in a bloody battle which resulted, his nephew Tokiwhati, with others of the Nga Puhi, was taken prisoner. Tuwhare, who was wounded in the same fight, and died shortly afterwards at Mokau, on his way to the Bay of Islands, learned that Tokiwhati was still alive, and entered into negotiations for his release. Either as a gift or ransom the treasured suit of armour was handed over to Hori Kingi te Anaua, uncle of the late Major Kemp. The armour was placed in the sacred house at Pukehika, opposite Jerusalem, till the walls of that edifice were tumbling down, and Hore Pukehika, a relative of the late Hori Kingi, and the present Native Sanitary Inspector for that district, hearing that some Europeans were planning how to carry off the relics, concealed them very carefully near the pa. This was thirty or forty years ago, and the armour lay undisturbed till a few weeks ago. Then Hori Pukehika and Dr. Pomare sought out the place, and, after laborious searching (for the scrub and other features had changed a great deal in the interval) discovered the old armour, rusty, but quite recognisable.

The armour consisted of plate armour for the back and chest, and pieces for the arms. It is much eaten with rust, but, considering that it is stated that it has been buried, is in fair preservation. It is fastened together with brass studs.

On looking into the details of the story given, and comparing them with the known and recorded facts concerning Hongi's armour, it became apparent that the history of the armour was incomplete, and that there were serious discrepancies.

In the first place, Earl, in 1827, speaking of the visit of Hongi to England in 1821, mentions that George IV gave him, amongst other presents of value, "a superb suit of chain armour and a splendid double-barrelled gun."* Taylor also speaks of Hongi giving the coat of mail to one of his sons when on his death-bed in 1827.† There are at least two other notices, the earliest of which is in Angas's "Savage Life and Scenes," 1847;‡ and I must give this in full, as it contains several details which are of interest. Angas writes from Paripari, Mokau, "At a small pah not far from the abode of his pakeha (Lewis), Taonui the chief has his residence. He is one of the most powerful and superstitious of the old heathen chiefs. . . . . He has also in his possession the original suit of armour that was given by King George IV of England to the Bay of Islands chief (E'Hongi), when that warrior visited England. The subsequent history of this armour is some-

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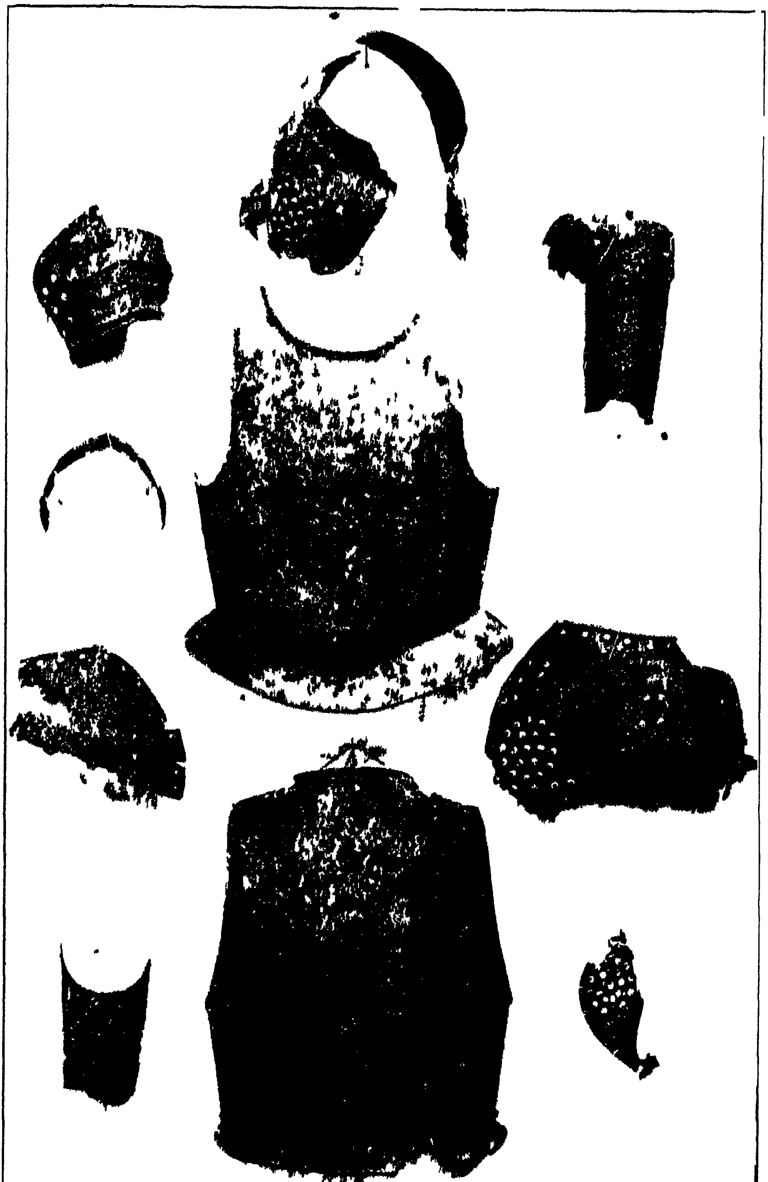
* Earl, "New Zealand," p. 62. 1827.

† R. Taylor, "Te Ika a Maui," pp. 310 and 315. 1855.

‡ Angas, "Savage Life and Scenes," p. 86, vol. ii. 1847.



ARMOUR PRESENTED TO TITORE —Hamilton

what curious: it passed from the Nga Puhi to Titore, and from Titore to Te Whero Whero, at the Waikato feast, and came into Taonui's hands under the following circumstances: On the death of a favourite daughter, Te Whero Whero made a song, the substance of which was that he would take off the scalps of all the chiefs except the Ngaweka and fling them into his daughter's grave to revenge her untimely death. The words of the song highly insulted the various individuals against whom it was directed, more especially as it was a great curse for the hair of a chief, which is sacred, to be thus treated with contempt. But the only chief who dared to resent this insult from so great a man as Te Whero Whero was Taonui, a chief of Nga Puhi and Ngati Whatua, who demanded a *taua* or gift as recompense for the affront, and received the armour of E'Hongi in compensation. I made a drawing of the armour, which was old and rusty: it is steel inlaid with brass; and, although never worn by the possessors in battle—for it would sadly impede their movements—it is regarded with a sort of superstitious veneration by the Natives, who look upon it as something extraordinary."

There is another extract which I will give, from Thompson's "Study of New Zealand," as it relates to information obtained by him in 1849.* "This armour" [Hongi's] "is now scattered about the country. In 1849 I found the breastplate in the possession of a chief living near the source of the Waipa River; in 1853 Waikato, the chief who accompanied Hongi to England, told me he had buried the helmet with his son's bones a few weeks before my visit to him at the Bay of Islands."

Both of the latter extracts refer to Hongi's "armour." The first gives the details of its passing from Titore to Te Whero Whero at the Waikato feast,† but both extracts describe the armour sufficiently to make it clear that it was not chain armour, but plate armour.

It is evident, therefore, that, if the relics deposited by Dr. Pomare were Hongi's, he must have had a suit of mail and a suit of plate armour. Earl, in his book published about the year of Hongi's death, distinctly mentions "chain armour," and in this he is supported by Taylor. Angas and Thompson speak quite as positively to its being plate armour.

Then, it is stated by the Whanganuis that the armour was given as a ransom for Tokiwhati. Now, Tokiwhati was wounded and captured by the Whanganuis in the course of Tuwhare's third expedition or war party, the survivors of which reached their homes at the Bay of Islands about October, 1820. Now, we know that Hongi, who returned from England to the Bay of Islands 11th July, 1821, wore his coat of mail at the capture of Mokoia Island, at Lake Rotorua, in August or September, 1823. It is also recorded that Hongi had a narrow escape at this battle. He was struck by the bullets of the Arawa from one of their few guns, and one bullet fired by the hand of Te Awa-awa struck his steel cap and knocked him over into the hold of the canoe. Mr. Percy Smith thinks that Hongi probably used the armour at Mauinaina, November, 1821, and at Te Totara. It is therefore quite clear that the ransom of Tokiwhati could not have been the armour of Hongi.

The whole question at this time seemed to turn on deciding who was correct, Earl and Taylor or Angas and Thompson.

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* Thompson's "Study of New Zealand," p. 256.

† This is the great feast held at Remuera, 11th May, 1844.

I made inquiries as to Hongi's armour from Mr. Stowell (Hare Hongi), a descendant of Hongi-nui, and by great good fortune was able to obtain from him some documents which settle the question. The first document is from Titore to King William IV: "Letter from Titore, Chief of Nga Puhi, to King William IV." Undated, probably 1831.

"KING WILLIAM, Here am I, the friend of Captain Sadler. The ship is full, and is now about to sail. I have heard that you, aforetime, were the captain of a ship. Do you therefore examine the spars, whether they are good or whether they are bad. Should you and the French quarrel, here are some trees for your battleships. I am now beginning to think about a ship for myself: a Native canoe is my vessel, and I have nothing else. The Native canoes upset when they are filled with potatoes and other matters for your people. I have put on board the 'Buffalo' a *mere pounamu* and two garments: these are all the things which New-Zealanders possess. If I had anything better, I would give it to Captain Sadler for you.

"This is all mine to you mine, Titore, to William, King of England."

["True copy of translation.—Henry M. Stowell, 3 Sterling Street, Berhampore. 7/12/08."]

The following is the reply:—

"The Earl of Aberdeen, one of His Majesty's Principal Secretaries of State, to His Highness Titore.

"FRIEND AND BROTHER,—

"I have received the commands of my most gracious sovereign King William the Fourth, to thank you for your letter, brought to him by the hands of Captain Sadler, commander of His Majesty's ship the 'Buffalo,' and for the assistance which you rendered to him in obtaining the articles for which that ship was expressly sent to your country.

"King William will not forget this proof of your friendship, and he trusts that such mutual good offices will continue to be interchanged between His Majesty's subjects and the chiefs and people of New Zealand as may cement the friendship already so happily existing between the two countries, and advance the commercial interests and wealth of both.

"The King, my master, further commands me to thank you for your present, and in return he desires you will accept a suit of armour, such as was worn in former times by his warriors, but which are now only used by his own Body Guard.

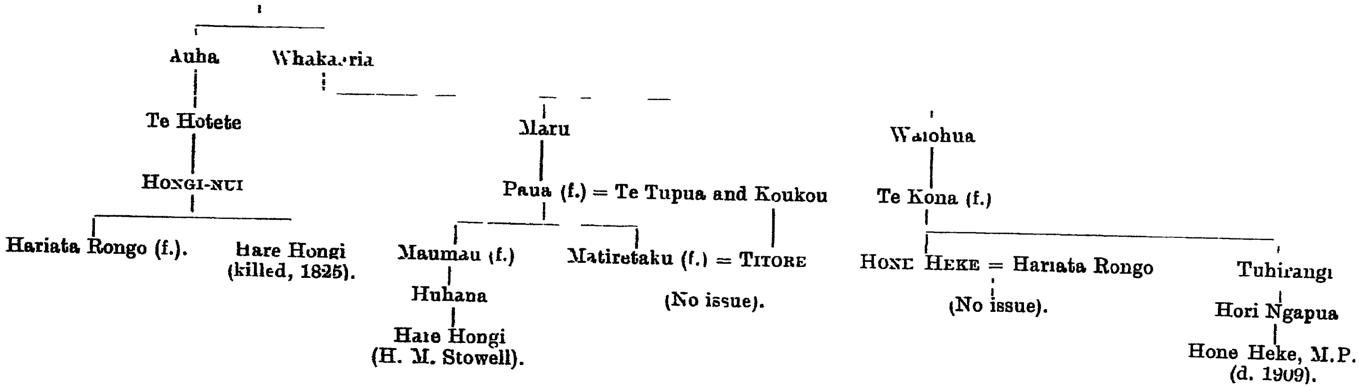
"This letter, as well as His Majesty's Royal present, will be conveyed to you through James Busby, Esq., His Majesty's authorised Resident at the Bay of Islands, whose esteem and friendship you will do well to cultivate, and who in his turn will do all in his power to promote your welfare and that of your countrymen.

"I am your Friend and Brother,
"ABERDEEN.

"Colonial Office, London, 31st January, 1835."

The armour is undoubtedly the suit presented to Titore as a recognition of his services to the captain of the "Buffalo." Although not Hongi's armour, it is still Nga Puhi, as will be seen from the following *whakapapa* showing the relationship between Hongi and Titore. I am indebted for this genealogy to Mr. Stowell (Hare Hongi).

FAMILY CONNECTIONS, HONGI AND TITORE.



The question of the whereabouts of Hongi's armour was discussed by some of the chiefs of Nga Puhi lately, but it seems to have disappeared. It is supposed by some to have been stolen by two slaves. Being chain armour, it would disappear more quickly in a mass of rust than plate armour. I am informed that for many years after Hongi's death the armour lay in a solid wooden box deposited in the midst of a clump of tea tree (manuka) (a *wahi tapu*) near the spot where Hongi died, at Papuke, Whangaroa. On the death of his son Hare Hongi, in the eighties, the various weapons and relics of his illustrious father were gathered up and placed round him at his tangi, and buried with him. There can be no mistake about Hongi's armour, as it is inscribed as presented to Hongi, a prince of New Zealand, by H.M. George IV, with date of presentation.*

If there is, as my correspondent says, an inscription on Hongi's armour, it can only have been on the cap. Judging from a sketch made from life by Gilfillan, in which Hongi is wearing what might be a steel cap, the cap and shirt of mail might have been of Indian workmanship.

It is fairly certain, from Native tradition, that at the peacemaking after the fall of Mokoia Hongi gave his helmet to the man who had "killed" him, Te Awa-awa; and many persons believe it to be buried in that district (Mokoia) at the present time.

Subsequently I received from my friend Wiremu Hipango, of Waitotara, a correct account of part of the history of the armour. He says, "It was myself and Hori Pukehika, at my request, made a search in 1892 and found it. The helmet could not be found. I heard afterwards it was buried in Pipiriki Cave.† I have heard from my own people that the armour belonged to Titore, a Nga Puhi chief, and is not the armour that Hongi had. Titore's armour was given to Te Wherowhero, and by him to Te Heuheu, the Taupo chief, and he it was who gave it to a relative of his named Aperahama Ruka, who married Wiki Tumuo, a niece of Hori Kingi. Te Anaua (uncle to Major Kemp), Ruka, and his wife brought it to Whanganui, and presented it to Hori Kingi te Anaua, and they kept it at Pukehika Pa. Another part of the story I was told: Titore was told a gun could not pierce the armour. Titore put it on, and told his son to aim straight at his head and fire. The son took his gun and made steady aim, but he was shaking so he told his father to take the armour off. So it was placed on a stump, and he took the fire. The bullet ran through. So his son said to his father, 'Ha! if you had had that on, you would be a dead man.' If the helmet were to be found I believe the bullet hole could be seen. I believe that to be the reason why Titore would not care to keep it any longer. The armour was presented to Titore in Sydney. As to Tokiwhati's present, it is another matter."

A little later I made further inquiries from Mr. Percy Smith, and he wrote to Wiremu Hipango, and Wiremu wrote to Tawhiao, of Taumarunui, and afterwards sent Mr. Smith the following letter, which is interesting, and explains some things rather more in detail:—

"To Mr. Smith. [Translation.]

"Salutations in this new year. Here is the letter of Tawhiao of Taumarunui, explaining about your letter to him asking for information as to the *kahu-maitai*" [suit of armour] "which was found by Dr. Pomare, and who has given it to the Museum containing the curiosities at Wellington. I am very glad that it has fallen to me to explain this, because I have seen in the *Dominion* newspaper which says, 'This is a peace-offering by Tuwhare to Te Anaua' (*i.e.*, to Hori Kingi). This is mere supposition, because Tuwhare came from Nga Puhi, hence the people think he owned the armour (that was the origin), and also because they heard that Hongi visited England and brought back some armour. Thus it has been thought ever since that it was Hongi's. I confirm the story of the peacemaking between Tuwhare and Hori Kingi te Anaua in reference to Tokiwhati. It was at the Kohimarama conference that the generosity of Nga Puhi was laid before Whanganui, which has lasted to this day. There was no armour with Tuwhare when he was fighting Whanganui; had there been, the fact would not have been lost in the history of the old men of Whanganui; there would have been 'sayings' about it. As, for instance, the news of Nga Puhi's guns, which was handed down by the escapees from the Nga Puhi fights, when our people of the South said, 'Let those *pu* (guns) come to their *pu*,' and then they sounded their *pu-kaea* (or trumpets).* When they saw the real meaning of those *pu*, then did Whanganui apply the .words to the *koanga kaahu*" [? armour], "and hence the origin of the story about Tuwhare.

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* Letter from F. J. Hagger, Esq.

† This I believe to be incorrect. It was, I am informed on good authority, for many years at Taumarunui, but has now been lost. (Trans. N.Z. Inst., xxxviii, pl. xvi.)

"But let me return to my story. This property (the armour) belonged to Te Heuheu the Great. The daughter of Te Anaua, Nga-weuweu, married Aperahama Ruke, a chief of Taupo, and the property descended to them, and was brought by them to Whanganui, and was left with Hori Kingi as a valuable property for Whanganui.

"Here is another reference to this matter. Hori Kingi te Anaua had two wives, both chieftainesses, Te Ao-tarewa of Ngati Ruaka, and Te Hukinga-huia of Ngati Ruru. In consequence of neither of them having children, they prepared a wooden image as a baby. Then Te Aotarewa composed an *oriori*, or lullaby, beginning 'Taku tamaiti e, i puta nui ra koe i te toi ki Hawaiki,' &c. (which may be seen at length in Tu-wha-whakia's narrative in your paper)" [*vide* Jour. Polynesian Soc. vol. xiv, p. 135]. "Te Anaua and his brother Te Mawae had also a lullaby about their image, part of which refers to the armour and to Te Heuheu: 'Kaore te whakama ki te kore tamariki i a au,' &c." [I do not see the application, however.—S. P. S.]

"This is the continuation of the story. The armour descended to the chief, and finally to me at Whanganui. I will now explain how this property came to Titore. It was sent to Port Jackson and thence to Titore. The fame of this armour was that bullets would not pierce it. It was then put on by the old man" [? Te Anaua] "who then called on his son to shoot at him; and when the distance had been arranged, the son took his gun and prepared to fire, but was very anxious about the result. So he said to his father, 'Take off your garment (*i.e.*, armour), and let me try it first, or put it on a stump,' to which the old man consented. Then he fired at it, hitting it on the forehead, and the bullet went through it. Said the son, 'If I had listened to you, you would have been shot dead.'

"If the helmet should be found, the hole in it will also be seen. One of my old men has just returned to Whanganui, and he told me that he had seen the helmet, with the hole through it on the forehead, but he did not know from whence the armour came. Now you will understand.

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* They, in fact, understood the modern word *pu* (gun) for the ancient word *pu* (a trumpet).

"Now, my urgent desire is that this property shall be permanently left in the Whare-Ruanuku (Museum). It was I that directed the search for it in 1895, and Hori Pukehika and I found it concealed in a place, that had been lost" [*i.e.*, the recollection of it]. "Last year Hori Pukehika and Dr. Pomare brought it away. Pukehika has only just returned" [? from here]. "I have sent a communication to Mr. Hamilton, but not so lengthy as this. Will you send him the enclosed copy? I have also sent to Hakiaha Tawhiao in case he should feel dark" [anxious] "on account of that property. Hence do I say that this property of Whanganui should be left in the Museum for ever.

"Enough. May you live, the only old man left of those other old who have departed to the night, Major Keepa, Mete Kingi, Hori Kingi, and many others.

"Your friend,

"W. Hipango."

Art. VIII.—*The Present Position of New Zealand Palæontology; with a List of Papers on the Palæontology of New Zealand, including the Titles of those Stratigraphical Papers containing Important Lists of Fossils.*

By A. Hamilton.

[*Read before the Wellington Philosophical Society, 6th October, 1909.*]

Geological explorations in New Zealand have been in progress now for seventy years, and a mass of reports and papers is in existence bearing witness to the work done by solitary pioneers, and later by—

The Provincial Surveys of Canterbury, 1860, under Haast; Otago, 1861, under Hector; and Wellington, 1862, under Crawford:

The Geological Survey established under the New Zealand Institute Act of 1867:

The officers of the Mines Department from 1878 to date: and

The new Geological Survey of 1905.

In addition to this there was the important work done by Hochstetter, and by Haast and Hutton and others, as private individuals.

The portions of this work that I wish to deal with are the collections that were made by those Surveys; and I wish to give, if possible, some idea of the progress that has been made with the study of them, and more especially what has been done in the examination and determination of the fossils.*

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* I do not propose to say anything about the collection of rocks and minerals, except to state that the collection of these made by the old Survey of 1867 in the Dominion Museum building exceeds 12,000 specimens; nor do I propose to say anything about the work that has been done on the moa and other extinct birds

The collections that are *in New Zealand* are not many, and may be described as under:

(1.) The collection of the older provincial Surveys and of the Geological Survey of 1867. These are in the Museum at Wellington. The number of specimens available for study is about 120,000. All these have correct locality numbers.
(2.) The displayed collection in the Canterbury Museum.
(3.) The displayed collection in the Auckland Museum.
(4.) The displayed collection in the Otago University Museum, Dunedin.
(5.) The Hochstetter collection in the Nelson Museum.
(6.) A few small private collections.

Outside New Zealand.

(7.) Collection of Tertiary fossils in the British Museum.
(8.) Specimens in the hands of experts for determination.

I will now say a few words about these collections, and as some justification for doing so I may say that I have been intimately acquainted with the collectors and the collections made by the Government Surveys for thirty-two years, and have watched their growth under the guidance of Sir James Hector, ably assisted by Mr. A. McKay, Professor Park, Mr. Cox, and others. It is with pleasure that I bear witness to the great interest and value of the collections. There can be little doubt that the cost of making the collections has been not far short of £50,000,* and some of them could not be secured again at any price.

At the end of this paper I have placed a bibliography of the papers bearing more especially on the palæontology of New Zealand; and those who are acquainted with the subject will see, on looking it over, that, except in the case of the Tertiary fossils, there has been very little systematic work recorded. Even the Tertiary lists must shortly undergo a severe revision, based on the new manual of the marine *Mollusca*, which is now near completion. The percentages of recent and extinct forms will be greatly modified. Much also remains to be done in carefully collecting with a view to establishing characteristic zones in the marine Tertiaries.

No serious systematic work has been done on the description of the Mesozoic or Palæozoic fossils.† It was the intention of the late Sir James Hector to bring out a series of publications on the palæontology of of New Zealand, and as early as 1878 the following reports were announced as specially descriptive of the palæontology of New Zealand: -

(1.) New Zealand Belemnites.
(2.) New Zealand *Brachiopoda.*
(3.) New Zealand Fossil Flora.
(4.) Fossil Corals.
(5.) Tertiary *Mollusca.*

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* Or perhaps one-half the total cost of the survey under Sir James Hector.

† A sufficient study of the fossils has been made to determine the probable age of the Lower and Upper Silurian, Lower Devonian, and Carboniferous formations in the Palæozoic series, and of the Permian, Triassic, Liassic, and Jurassic sequence of the Mesozoic formations, and the determinations yet to be made are not likely to disprove the general accuracy of the conclusions that have been arrived at with respect to these formations.

Of these, the fourth was printed and issued with plates, being a descriptive catalogue of fossil corals and *Bryozoa* sent to the Sydney Exhibition in 1879, written by Rev. Tenison-Woods.

One (the first) was to be on the belemnites; and the plates for this part were published in the "Transactions of the New Zealand Institute,"* with an abstract of the descriptions by Sir James Hector. A sufficient supply of extra plates was printed for the separate issue, and are still in store.

The same course seems to have been taken with the palæozoic *Brachiopoda*, although in this case additional plates are in existence besides those that were printed for a separate issue. Three new genera, *Rastelligera*, *Psioidea*, and *Clavigera*, are proposed in the abstract published.† The plates as prepared figure thirty-three species in thirteen genera. Plates v, vi, vii. viii have not been printed, although the drawings are arranged. Besides this there are drawings, not arranged, for about four more plates. A paragraph on page 539 states that " These two papers " [on the fossil flora and on the fossil *Brachiopoda*] " will appear in full in the report of the Geological Survey Department now in the press " [January, 1879].

There is another paper in the form of a translation of Ettingshausen's paper on the fossil plants of New Zealand. This appears in the Transactions,‡ and a few copies were issued with separate pagination, and the extra supply of plates was printed off and stored.

It is possible that another palæontological report was in contemplation, as there is an extra supply of plates printed corresponding to those of the paper on the fossil *Reptilia* of New Zealand.§ A number of blocks were made of characteristic fossils from drawings by Buchanan—the draughtsman to the Survey—and were used in the Catalogue and Guide to the Geological Exhibits at the Indian and Colonial Exhibition in London in 1886.

It is much to be regretted that apparently no manuscript by the late Sir James Hector exists to enable his work to be taken up. I have been able to identify the figures in Buchanan's drawings of the brachiopods by the number on the drawings and the number on the specimens still in the case. Whether it is worth while to endeavour to retain those names remains to be seen. The three genera proposed by Sir James are entitled to stand so far as publication is concerned. A very large series of specific names are used in the introductions to the annual reports of the Geological Survey; but, as they have not been printed with any author's name, it is difficult to identify them, especially as they are not attached to any specimen.

The catalogue of the Tertiary *Mollusca* and *Echinodermata* by Captain Hutton was issued in 1873.

In the general collection at the Museum the only named specimens are a few of Hutton's types of the Tertiary *Mollusca*, and the collection of fish-teeth examined by Davis,‖ and a few of the reptilian remains which can be identified by the published plates. Probably the plant-fossils named by Ettingshausen are also still named, although they have been packed away for years. The number of named New Zealand fossils in the Museum other than types is certainly well under fifty.*

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* Trans. N.Z. Inst., vol. x, p. 484, pls. xxii, xxiii.

† Trans. N.Z. Inst., vol. xi, p. 537.

‡ Trans. N.Z. Inst., vol. xxiii, p. 237, pls. xxiv–xxxiii; Trans. N.Z. Inst., vol. xi, p. 536.

§ Trans. N.Z. Inst., vol. vi, p. 333, pls. xxvii–xxxi.

‖ Trans. Royal Dublin Soc., vol. iv, ser. 2. 1888.

There is one important matter which I consider should be placed on record which is at present buried in departmental files. In 1885, at the request of Professor Tate, of Adelaide, a collection of fossils from the New Zealand Tertiaries was sent to him; and again in 1890, at the request of the late Captain Hutton, a collection of the New Zealand fossil pectens was sent for comparison with the Tertiary fossils of the Australian regions, which the professor was then describing. He appears to have drawn up a report, but desired better and more specimens. This was attended to, and practically all the pectens in the collection were sent, the list of which covers eleven folio sheets, the collection itself filling many cases. Shortly after this, Professor Tate died; and frequent applications were, I believe, made for the return of the specimens, without avail. I understand that at the professor's death it was found impossible for the University authorities to separate the University collection from those belonging to the professor and those loaned to him. We have suffered, at any rate for the present, a great loss. The loss is important, as the pectens as a rule afford important stratigraphical information from a zonal point of view. From an interview which I had not long ago with an Adelaide gentleman, I believe it would still be possible to recover some of the specimens.

To return to our list of collections: The second is that displayed in the Canterbury Museum; and, when we remember that for some years Dr. Von Haast and Captain Hutton devoted much time and labour to it, we shall not be surprised to find here probably the best-arranged and best-named collection of fossils, mainly Tertiary, in the Dominion. The collection was worked over some years ago by Mr. Suter, and is in good condition, and well arranged in a pattern of case which originated in the Museum, and is mentioned with approval by Bather in his report on antipodean museums. There is also the finest collection of remains of the *Dinornis* that yet has been exhibited; and the whole is supplemented by a large collection of fossils from other countries. It contains many types of Hutton's species. It would be very convenient to have a published list of this collection, with types indicated.

The third collection is that in the Auckland Museum. Mr. Cheeseman informs me that, with the exception of a few well-known species, they have less than fifty named fossils to represent the Palæozoic and Secondary fossils. In the Tertiaries their collections are larger, but still far from satisfactory.

The fourth is the small collection exhibited in the Otago University Museum. Here for some time the New Zealand and foreign fossil species were exhibited in their places with the living species; but Professor Parker, recognising that the Museum was devoted more especially to teaching-collections, as distinguished from large general collections, largely reduced the number of exhibits, and substituted instead a very carefully selected series of fossils from all countries illustrating the sequence of life-forms in geological order. The number of specimens is small, but the value is great for teaching purposes, set out as it is with instructive labels at frequent intervals. The collection of moa-remains is notable, including several individual specimens and a complete egg, together with some excellent osteological preparations of the juvenile states, and the originals of the plates in Professor Parker's paper on the cranial osteology of the moa.

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* In the Rep. N.Z. Inst., 1877–78, it states that "The New Zealand fossils now accumulated in the course of the Geological Survey represent collections from 450 different localities, and comprise about 6,200 trays, which have been thoroughly classified, and 1,200 specific types withdrawn into a separate collection for publication. A large number of types have been figured, and their publication will be proceeded with as rapidly as the other work of the Department will permit."

The fifth is the Hochstetter collection of rocks and fossils presented to the Nelson Museum by Hochstetter, and, when the Museum was destroyed by fire a few years ago, it was much damaged. Now, however, it has been cleaned and restored.

The remaining head of my list includes a number of small collections that are the property of private collectors. None of these are of any great extent, and they are mainly from the Tertiary beds.

The collections outside New Zealand are not many or extensive, but include the following:—

In the year 1860 the Hon. W. B. D. Mantell presented a collection of *Mollusca* from the Miocene and Pliocene beds at Awamoa and Onekakara to the British Museum.

In 1875 a large and valuable collection was taken Home by Sir James Hector from various horizons in the Tertiary of New Zealand, and exchanged with the British Museum authorities, and in 1880 a few were transferred to the British Museum from the Museum of Practical Geology. A few were presented in 1882 by Lieut.-Colonel Wilmer from the Pliocene and Post-Pliocene, and a few by Mr. Bullen from a raised beach near Opua, Russell, Bay of Islands. These specimens were described and three species figured in the Australasian Section of the Catalogue of the Tertiary *Mollusca* in the Department of Geology, British Museum, by G. F. Harris, F.G.S., in 1897, the New Zealand species being 108 gasteropods, with 42 lamellibranchs.

In 1904 Professor Park collected a large number of fossils from a new locality on Mount Mary on the Upper Waitaki, and these were forwarded to Professor Boehm, Freiburg, for examination. He has been obliged to hand them over to Dr. Otto Wilckens, Associate Professor of Geology, Bonn University, for description, and we are still waiting for the issue of the publication. Some collections have been made in the older rocks of the Nelson District, and are, I believe, being examined at the British Museum at the present time.

In the same year Professor Park and the writer made large collections of fossils from the Triassic and Jurassic rocks at Nugget Point and Catlins district. These fossils, supplemented with collections made by Professor Park from the Trias of Nelson, are now in the hands of Professor Wilckens awaiting description.

When we come to inquire into the literature that is available, we have at present to rely largely on the results of the "Novara" expedition and the determinations of Zittel for the Triassic and Jurassic rocks. Fortunately, the publications of that voyage are available in most of the libraries, and the plates are excellent. The work, however, only figures fifty species of *Mollusca* from all formations, together with nine quarto plates of *Foraminifera* and *Bryozoa*—quite a creditable result, however, under the circumstances.

Scattered through the pages of the series of the New Zealand Geological Reports are a great number of generic and specific names, a very large proportion of which will be found on examination to be "*nomina nuda*," and will disappear.

In the catalogue of the New Zealand fossils exhibited at Sydney particular pains seems to have been taken to affix names to the exhibits. From the list I have extracted all that could be taken with any hope of tracing them, and arranged them under authors, placing the letter M against those species that can now be identified in the Museum collections.

In Catalogue of Fossils exhibited at Sydney by Colonial Museum.

- Salter—
  - Orthis patera. M.
- Hall—
  - Murchisonia terebralis.
  - Orthis fissicostata. M.
  - Callopora elegantula.
  - Astrocerium venustum.
  - Orthis circulus. M.
  - Streptelasma junceum.
  - Orthoceras junceum.
  - Murchisonia uniangulata (*var.* abbreviata).
  - Modiolopsis modiolaris.
  - Leptæna bipartita. M.
- Davidson—
  - Strophomena corrugatella.
    - d'orbignyi. M.
  - Orthis interlineata. M.
- Phillips—
  - Avicula anisota.
    - cancellata.
  - Monotis radialis.
  - Belemnites australis. M.
- Dalman—
  - Orthis basalis.
  - Chonetes striatella.
- Lindstrom—
  - Orthis crassa. M.
- Sowerby—
  - Orthis unguis.
  - Spirifera radiata.
  - Stricklandia lyrata.
  - Rhynchonella wilsoni. M.
  - Trigonotreta undulata.
  - Mytilus squamosus.
  - Astarte minima.
- Sowerby—*continued.*
  - Astarte elegans.
  - Trigonia costata.
  - Avicula costata.
- Brongniart—
  - Calymene blumenbachii.
- Konig—
  - Homalonotus knightii.
- Romer—
  - Spirifera cultrijugata.
- Hector—
  - Homalonotus expansus.
  - Psioidea, *nov. gen.* M.
  - Rastelligera, *nov. gen.* M.
  - Belemnites otapiriensis.
    - pallinensis.
    - hochstetteri.
  - Trigonia sulcata.
- Schlotheim—
  - Spirifera speciosa. M.
  - Epithyris elongata. M.
- Geinitz—
  - Schizodus schlothemii.
  - Nautilus frieslebendi.
- Zittel—
  - Mytilus problematicus. M.
  - Spirigera (Athyris) wreyii. M.
  - Monotis salinaria. M.
  - Aucella plicata.
- Hochstetter—
  - Inoceramus haasti.
- Hauer—
  - Ammonites novo-zelandicus.
  - Belemnites aucklandicus.
- Brown—
  - Pleurophorus costatus.

In the list of papers given at the end there are some in which further assistance in the identification of species may be found; but there is a great lack of information until we come to the Tertiaries.

It will be seen from this short summary that the student of geology has plenty of palæontological material that might be available for him to work on under expert guidance, but that the literature relating directly to his work is small, scattered, and hardly up to the present level of research. This is not a new discovery—the matter has been discussed for many years. The subject is a difficult one, as it requires not only a thorough knowledge of the progress of modern systematic work in classification, but a working knowledge of the mass of published literature on the rocks of similar age found in other countries. Unless this is taken into account, the result will be a useless multiplication of genera and species, and a further burdening of a synonymy already of bewildering length.

At the meeting of the Australasian Association for the Advancement of Science held at Dunedin in 1904, the subject of New Zealand palæontology was brought up, and the President, Professor David, waited on the Minister of Mines and communicated the following recommendation from Section C, which had been agreed to by the association:—

"NEW ZEALAND FOSSILS.

"On the recommendation of Section C, it was agreed, That the following resolution be forwarded to the New Zealand Government: That, whereas this association considers that the description of the large collection of fossils now at the Wellington Museum is one of the most important services which the New Zealand Government could at the present time render to science, and that it is one which would be for the advancement of science throughout the world; that, whereas the work would be of economic as well as of scientific interest, as it is only by its means that the coalfields of New Zealand can be properly correlated, and the broad relations and modes of origin of its metalliferous deposits understood; that, whereas, according to the annual reports, there are more than thirty thousand fossil-specimens in the exhibition-cases at Wellington Museum, by far the larger part of which are unnamed and undescribed, and besides about five hundred boxes of fossils still unpacked in the same Museum; and that, whereas these collections, made at considerable expense to New Zealand, are obviously useless in their present state—this Council recommends: (1.) That the description of these fossils should be commenced immediately, and that, if this recommendation is adopted by the New Zealand Government, the undermentioned groups of fossils be sent for description to the following workers at once: The graptolites, to T. S. Hall, M.A.; the *Foraminifera* and ostracods, to F. W. Chapman; the echinoids, to Professor Gregory; Palæozoic fossils other than those in the above groups, to R. Etheridge, jun. (Curator, Australian Museum, Sydney), and W. S. Dun (Palæontologist, Geological Survey, New South Wales). (2.) That, with regard to the large and important collections of Mesozoic and Cainozoic fossils (other than echinoids, *Foraminifera*, and ostracods) in the Wellington Museum, the Council recommends that advice as to their description be delegated, so far as this association is concerned, to a committee consisting of the following: Captain F. W. Hutton (retiring President), Professor Baldwin Spencer (President-elect), and A. Hamilton, Esq. (Director of the Colonial Museum, Wellington)."

The Hon. the Colonial Secretary was also written to to the same effect, and did me the honour to forward the letter for my perusal, and asked for my views on the matter; and I replied as follows:—

"Feb. 9th, 1904.

"To the Hon. the Colonial Secretary, Wellington.

"SIR,—

"I am obliged to you for the opportunity to peruse the letter addressed to the Premier by the President of the Australasian Association for the Advancement of Science, and I am glad to have the opportunity of expressing my views on the subject of the description of the fossils in the Museum, although that part of the collection has not passed under my charge.

"I think that it is imperative that steps should be *taken at once* to have the fossils (other than the Tertiary fossils) got together and prepared for examination and description by an expert. Without this preliminary step no arrangement could be come to with any expert, either as regards the description and figuring or the publication of results. He must know whether he is to deal with hundreds or thousands of specimens. This matter of getting the material together is urgent, as the only person thoroughly acquainted with the whole of the specimens is Mr. McKay.

"I concur in the suggestions made generally, and I can assure you that the feeling of geologists and men of science all over the world is that this matter is urgent. The conditions under which the arrangements are made with the experts employed must be carefully framed, and will need much consideration. "I am, sir, your obedient servant,

"A. HAMILTON, Director."

Further suggestions were asked for, and I wrote as follows:—

"To the Hon. the Colonial Secretary. "Feb. 26, 1904.

"SIR,—

"In reply to your memo. of the 24th instant, *re* the fossils of the New Zealand Geological Survey at present in the Museum under my charge, and the proposed arrangements for their description and publication. I have the honour to make the following suggestions and remarks:—

"1. *Preparatory Work.*

"(*a.*) That the Mines Department be asked to instruct their officials to get together in a convenient place all the specimens of fossils now in their collections up to the close of the Cainozoic period, arranged generally under the following heads:—

"Hydrozoa,
Actinozoa,
Echinoderms,
Annelids,
Crustacea,
Polyzoa,
Brachiopoda,
Lamellibranchiata,
Gasteropoda,
Cephalopoda.

"(*b.*) That the number of specimens in each class be ascertained within reasonable limits, and that an estimate be made of the probable number of species.

"(*c.*) That the specimens be repacked in strong cases, and plainly labelled and numbered at the side and at the end of the case. A more detailed description of the specimens to be entered against the number of the case in a record-book. It is presumed that *all* specimens have already their locality number. When this preparatory work has been done,* which will take some months, the following steps should be taken:—

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* It is not quite finished yet.

"2. *Arrangements for Description and Publication.*

"(*a*.) Certain well-known experts in the Australasian Colonies should be approached as to their willingness to undertake the description of one or the other of the groups of fossils, and as to the terms on which they would do so, and also as to what they consider a fair and reasonable time in which to do the work.

"(*b*.) A draft agreement should be drawn up by the Government or the Department, setting forth, with the necessary blanks, what the expert contracts to do on his side, and what remuneration he is to receive for the work, and when and how he is to be paid.

"In making the above suggestions I wish to point out that the preliminary sorting and packing of the fossils is the most urgent matter, and should be seen to at once. Unfortunately, the accommodation at the Museum is at present quite insufficient for such work, and emphasizes the necessity for the workshops at the back of the Museum, which I trust will be soon authorised.

"However, as soon as the Government Analyst takes possession of his new building, the rooms he vacates could be used with advantage for the sorting. The Mines Department will no doubt give Mr. McKay what assistance he requires for the purpose, and provide suitable boxes for the repacking of the specimens. Directly the number is ascertained of the fossils to be examined and described, the Government should appoint one or more persons to interview the selected experts in Australia to arrange the terms and conditions; and I would suggest that, instead of visiting them separately, they should be invited to meet in Sydney and discuss with the New Zealand representatives a plan for the description and publication of the fossils, in order to insure as much uniformity as possible for the various New Zealand publications, and also that they should conform as far as possible to similar publications by the Australian States.

"I must call your attention to the extremely unsatisfactory result of some transactions with the late Professor Tate, of Adelaide, as disclosed by the file of correspondence in the office of the Museum. It seems that at his request Professor Tate was intrusted with a large collection of Tertiary fossils for description. The fossils have not been returned to the Museum, and I have recently been informed that the fossils have passed into the hands of a person who has sold or otherwise disposed of them.*

"Professor Tate furnished a few notes on a part of the collection which he received in 1890. It does not seem to me right that such a thing should occur, although I am not now in charge of the collection of which the lost specimens formed a part.†

"I am, sir, your obedient servant,
"A. HAMILTON, Director."

Since that time Mr. A. McKay and an assistant have been continuously employed in the transfer of the specimens of rocks and fossils to new and better boxes, and have checked every specimen as to locality, and a complete record has been made. It is fortunate that this has been done, as there is no one else now living who could have done it, and Mr. McKay, who has now retired from active work in the Mines Department, can look back with satisfaction on the present condition of the collection which represents the work of his life.

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* This, I now learn, is incorrect.

† Under the New Zealand Institute Act of 1903 the minerals and fossils in the Museum passed into the control of the Mines Department.

The work of bringing together, reticketing, and cataloguing the fossil collections in the Dominion Museum was begun in 1904. By Sir James Hector most of the collections were subdivided to bring together the genera of the families and orders represented, and it was determined to bring together in the collection all the specimens from each locality. This proved a most arduous work, and for want of sorting-space it was found to be impossible, and the specimens of one locality had often to be repacked in several boxes containing other fossils. Finally the ticketing, &c., was finished (excepting the brachiopods and cephalopods in the cases), and for some months past a revision and gathering of the fossils from one locality into as few boxes as possible has been going on. When this work is finished the whole of any collection can be laid out, and the different species culled from the evident duplicates of the same, and, thus pruned, the collection may be placed in the hands of an expert for description. There is even now plenty of material wherewith to make a start—as, for instance, in the large and important collection from Amuri Bluff.

Mr. McKay has also greatly elaborated the old lists of localities for the guidance of future collectors.

Since the meeting of the Australasian Association in Dunedin in 1904 a new Geological Survey, with Dr. Mackintosh Bell as Director, has been established, and the palæontological work done by the officers of the Survey will be found in the new series of Bulletins issued since that time.

Palæontology has naturally held a place in the training of the students who have passed through the various courses for certificates and diplomas of the School of Mines of the University of Otago, and it also forms a part of the subject of geology in the degree subjects for the University of New Zealand.

The results are, so far as I can gather, that, of our students who have attended the Otago School of Mines, twelve mining students have passed the requirements of the examination in general palæontology.

In the University of New Zealand 197 students* have, up to the present time, taken geology, including New Zealand palæontology, for the pass degree, with the following results: Passed, 197. For honours, 24 have taken geology, including palæontology: of these, 16 passed with first-class honours, 7 with second-class, and 1 with third-class. Of these honours students, Clarke, Thomson, Andrew, and Boult have contributed papers to the "Transactions of the New Zealand Institute," which appear under their names in the list at the end of the paper, Mr. Clarke describing as new 3 species, Thomson 3 species, Andrew 1 species of *Mollusca* and some cetacean remains, Boult 1 species; most of these being Tertiary species.

This paper is written to point out the present unsatisfactory position of New Zealand palæontology, and I have endeavoured to provide a base for a new departure when the opportunity occurs for a forward movement. I am convinced that so far as the Palæozoic and Mesozoic fossils are concerned there is little of permanent value on record, except in the "Voyage of the Novara" and one or two recent papers, and it will be necessary to make a fresh start in the description and correlation of the New Zealand species in the collection.

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* Bachelor of Arts, 107; Bachelor of Science, 84; Bachelor of Engineering, 6.

It will be found that fresh collections will have to be made in some localities to ascertain correctly the horizons and zones in which certain species occur.

List of Papers on the Palæontology of New Zealand, including the Titles of those Stratigraphical Papers containing Important Lists of Fossils.[*]

Andrew, A.

On the Geology of the Clarendon Phosphate Deposits, Otago, N.Z. Trans. N.Z. Inst., xxxviii. 447. [Pl. iv figures a new brachiopod—*Magellania marshalli*—and some cetacean bones.]

Bather, F. A.

The Mount Torlesse Annelid. Geological Magazine (n.s.), dec. v. vol. ii, pp. 532–541. December 1905. [And letter to editor, January 1906, pp. 46. 47, *ib.*]

Benham, W. B.

A Gigantic Cirripede from New Zealand. Geol. Mag. Lond. (ser. 2), 1903, pp. 110–119, 2 pls.

Boehm, Georg.

Ueber tertiare Brachiopoden von Oamaru, Sudinsel. N.Z. Berlin; Zs.D. geol. Ges. 56. 1904. briefl Mitt. (146–150, mit 1 Taf.).

Reisenotizen aus Neu-Seeland. Abdruck a. d. Deutsch. geolog. Gesellschaft. Jahrg. 1900. p. 169–177.

Boult, A.

Occurrence of Gold in Harbour Cone, Dunedin. [Incidentally describes and figures (p. 432, pl. ix, fig. 1) *Pseudamussium huttoni.*] Trans. N.Z. Inst., xxxviii, 425.

Buchanan, J.

On the Belemnite Beds at Amuri Bluff. Rep. N.Z. Geol., 1867.

Castracane.

Sul deposits di Jackson's Paddock, Oamaru, nella Nuova Zelandia. Roma, 1890, 4.

Clarke, E.

The Fossils of the Waitemata and Papakura Series. Trans. N.Z. Inst., xxxvii, 413; 1905.

Graptolites of the Aorere Series. Bull. No. 3 (N.S.), N.Z. Geol. Surv., 1907, p. 34, pl. viii.

Crawford, J. C.

On Probable Reasons why Few Fossils are found in the Upper Palæozoic and Possible Triassic Rocks of New Zealand. Trans. N.Z. Inst., ix, 561.

Davis, James William.

On some Fish-remains from the Tertiary Strata of New Zealand. (Paper afterwards withdrawn.) Jan., 1886. [Sent by Captain Hutton: Fish teeth and spines exhibited—*Lamna*, *Carcharodon*, *Notidanus*, *Myliobatus*, *and Sparnodus;* Te Aute.] Q.J. Geol. Soc., vol. xlii, pt. ii. p. 4; 1886.

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[*] This list does not include, except in a few instances, the papers that have been written on the subject of the fossil remains of the extinct birds of New Zealand. These have been given in the Transactions of the N.Z. Institute, vol. xxvi, p. 229; vol. xxvii, p. 229; vol. xxxvi, p. 471.

Davis, James William—*continued.*

Report on the Fossil Fish-remains of New Zealand. Trans. Roy. Dub. Soc., vol. iv, ser. 2 ; 1888. [See also N.Z. Geol. Rep. (as a separatum).]

Note on a Species of *Scymnus* from the Upper Tertiary Formation of New Zealand (*S. acutus*). [Napier series, Esk River.] Geol. Mag., n.s., dec. iii, vol. v ; 1888.

De Latour, H. A.

On the Fossil Marine Diatomaceous Deposit near Oamaru. Trans. N.Z. Inst., xxi, 293.

Duncan, P. M.

On some Fossil *Alcyonaria* from the Tertiary Deposits of New Zealand. Q.J. Geol. Soc., vol. xxxi, 1875, p. 675, pl. xxxvii.B.

Ettingshausen, Professor Dr. Constantin Freiherrn von.

Beiträge zur Kenntniss der Fossilen Flora Neuseelands. Besonders abgedruckt aus dem liii Bande der Mathematisch Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften. p. 1–52, taf. 1–9, vol. liii, pt. i ; 4to. Wien, 1887.

Genetische Gliederung der Flora von N.Z. Sitzungsbr. Imp. Acad. Sc. of Vienna, vol. lviii, pt. i, p. 953. 1884.

On the Fossil Flora of New Zealand. Geol. Mag., 363. 1887.

Contributions to the Knowledge of the Fossil Flora of New Zealand, Trans. by C. Juhl from the German (Vienna, 1887). Plants from seventeen localities. Tert., Cretaceous, and Trias. Trans. N.Z. Inst., xxiii, 237, plates xxiv–xxxii, redrawn by J. Buchanan. [This was reprinted as New Zealand Palæontology, pt. ii, Fossil Flora. pp. 1–74, and a supply of the plates from Trans., vol. xxiii, to issue with it. A few copies were issued.]

Etheridge, R., jun.

On some Species of *Terebratulina*, *Waldheimia*, and *Terebratella* from the Upper Tertiary Deposits of Mount Gambier and the Murray Cliffs, S.A. Ann. Mag. Nat. Hist., 1876, vol. xvii. p. 15. [*Waldheimia taylori*, Ett., pl. i, fig. 3, *a*, *b*, *c*, has been identified as New Zealand by Hutton, and other Australian Tertiary species will probably be found to be represented in New Zealand formations.]

Field, H. C.

A Fossil Egg. [In "shell-rock," Otatoka Valley, near Waitotara. 2 in. long by 1¼ in.] N.Z. Journ. Sci., ii, 325.

Forbes, Dr. C.

On the Geology of New Zealand, with Notes on its Carboniferous Deposits. Q.J. Geol. Soc., xi, 521.

Forbes, E., and Rupert Jones.

See Mantell. Forbes: Note on Fossiliferous Deposits in the Middle Island of New Zealand. [Jones: *Foraminifera* and Diatoms.] Q.J. Geol. Soc., vol. vi, p. 329 ; 1850.

Haast, Sir J. von.

Geology of Canterbury and Westland, 1879. Pt. iii, Geology: Waipara Formation, Fossil Contents, p. 295; Oamaru Formation, Fossil Contents, p. 311; Pareora Formation, Fossil Contents, p. 319; Saurian Remains in the Waipara, pp. 153–155.

Haast. Sir J. von—*continued.*

Saurian Remains from the Waipara River. Canterbury, in the Possession of J. Cockburn Hood. [Lost in the "Matoaka." A tooth figured, pl. xxiv. fig. G. *a*, *b*. *c*. Trans. N.Z. Inst.. vi (Knight).] Trans. N.Z. Inst.. ii. 186.

Saurien in der Tertiärform. in New Zealand. Wien Verhandl. Geol., 350 ; 1869.

Vorkommen von Brachiopoden im den Kusten von Neu Seeland. Wien Geol. Verhandl.. 253 ; 1874.

Hamilton, A.

List of Recent and Fossil *Bryozoa* collected in various Parts of New Zealand. Trans. N.Z. Inst., i–xxxvi, 1908, 465–467.

Notes on a Small Collection of Fossils from Wharekauri, on the Waitaki River. North Otago. Trans. N.Z. Inst., xxxvi. 465–467 ; 1904.

Harris, George F.

Catalogue of the Tertiary *Mollusca* in the Department of Geology, pt. i, Australasia ; 1897 ; British Museum (Nat. Hist.). [Localities 1, 5, 13, 14, and 15 are New Zealand. Describes species presented by Dr. Hector and others.]

British Museum Catalogue. Tertiary Fossils. New Zealand Section. 1897.

Heaphy, Charles.

The Volcanic Country of Auckland. N.Z. In an appendix to the paper, list of fossils, mostly *Foraminifera*, by the editor Q.J.G.S., T. Rupert Jones. Journ. Geol. Soc., 1860. vol. xvi. p. 251, pls. xii and xiii. (In Review of Karrer's paper, T. R. J.[ones] and W. K. P.[arker] in Geol. Mag., i. p. 75 ; 1864.)

Hector, Sir James.

Table of Fossiliferous Localities. Rep. N.Z. Geol. Surv., No. 13, 1879–80, iii.

Index to Fossiliferous Localities in New Zealand. Rep. N.Z. Geol. Surv., 255. 1886–87.

On the Fossil *Brachiopoda* of New Zealand (abstract). Trans. N.Z. Inst., vol. xi. p. 537.

Fossil *Reptilia* of New Zealand. Trans. N.Z. Inst., vi, 333, pls. xxvii to xxxi.

Index to Fossiliferous Localities in New Zealand, distinguished by Numbers. Rep. N.Z. Geol. Surv., 120 ; 1890–91.

Index to Fossiliferous Localities according to Counties. Rep. N.Z. Geol. Surv.. 146 ; 1890–91.

On a New Trilobite (*Homalonotus expansus*). Trans. N.Z. Inst., ix, 602.

Handbook of New Zealand. Sec. Geology, List of Characteristic Fossils in the various Formations : 1879 (Sydney), pp. 17, 30 ; 1880 (Melbourne), Appendix to Official Cat., with Geological Map, pp. 19, 32 ; 1883, pp. 24–41, with geol. map ; 1886. pp. 28–35.

Indian and Colonial Exhibition, 1886, N.Z. Court : Detailed Catalogue and Guide to the Geological Exhibits. [Pp. 1–88, with geologically coloured map of North and South Islands ; 65 sections and figures, about 184 figures of characteristic fossils. Though in many cases poorly drawn, they form the best series yet issued. Pp. 89–101 : Appendix to General Index to Reports and List of Publications of the Geological Survey of New Zealand.]

Hector, Sir James—*continued.*

Notes on N.Z. *Cetacea*, Recent and Fossil. In Proc. N.Z. Inst., vol. xiii. p. 434 (abstract only), pl. xviii. [Part of lower jaw, tympanic bulla, and teeth of *Kekenodon onamata*, nov. gen. and sp., Waitaki Valley. Types in Dominion Museum. See also Rep. N.Z. Geol. Surv., 1881. pp. xxviii and 68, with section; also (p. 104) recording a nearly entire specimen, 23 ft. in length, the fragments of which are now in the Museum.]

Outlines of New Zealand Geology, with Map. Second Part of Special Catalogue of Geological Exhibits sent to Indian and Colonial Exhibition. Also Appendix to General Index to Reports of Geological Survey. Rep. N.Z. Geol. Surv., 37. 1886.

Critical Notes and Corrections of Localities in "Report on the Fossil Fish-remains of N.Z.," by J. W. Davis. N.Z. Geol. Rep., No. 22. 1894, pp. 115–120.

Preliminary Note on the Bones of a Fossil Penguin. Trans. N.Z. Inst., ii. 403.

On the Remains of a Gigantic Penguin (*Palæeudyptes antarcticus*, Huxley) from the Tertiary Rocks on the Coast of Nelson. Trans. N.Z. Inst., iv. 341.

Further Notes on the Bones of a Fossil Penguin (*Palæeudyptes*). Trans. N.Z. Inst., v. 438.

On the Belemnites found in New Zealand. Trans. N.Z. Inst., x. 484.

Hill, H.

Description of a Scaphites found near Cape Turnagain. Trans. N.Z. Inst., xix, 387.

Hinde, G. Jennings, and Holmes, W. Murton.

On the Sponge-remains in the Lower Tertiary Strata near Oamaru, Otago, N.Z. Journ. Linnean Soc. (Zoology), vol. xxiv, p. 177–262, pls. vii to xv.

Hochstetter, Ferd. von.

Palæontologie von Neu Seeland. By Unger, Zittel, Suess, Karrer, Stoliczka, Stache, and Jaeger. Reise der "Novara," 2 abth. 1864.

Huxley, Professor T. H.

On a Fossil Bird and a Fossil Cetacean from N.Z. [*Palæeudyptes antarcticus*, Kakanui limestone; *Phocænopsis mantelli*, Awamoa (Pareora).] Q.J. Geol. Soc., xv. 671.

Hutton, Captain F. W.

Descriptions of New Tertiary Shells. [Pt. i, Wanganui and Petane, H.B.; pt. ii, from Canterbury Museum and Hawke's Bay.] Trans. N.Z. Inst., xvii, 313–322. pl. xviii, fig. 22.

Three New Tertiary Shells. [*Pleurotoma hamiltoni* and *Mitra hectori*, Waihao Forks, Cant.; and *Pecten hilli*, Napier.] Trans. N.Z. Inst., xxxvii, 472–473, pl. 44.

New Species of Tertiary Shells from Canterbury, Wanganui, and Petane. ["The list of New Zealand Tertiary *Mollusca*, 1885, numbers about 460 species, of which about 250 still remain unfigured."] Trans. N.Z. Inst., xviii, 333.

Revision of the Tertiary *Brachiopoda* of New Zealand. Trans. N.Z. Inst., xxxvii, 474–481, pls. xlv, xlvi.

On the Supposed Rib of the Kumi. Trans. N.Z. Inst., xxxi, 485.

Hutton, Captain F. W.—*continued.*

Catalogue of the Tertiary *Mollusca* and *Echinodermata* of New Zealand in the Collection of the Colonial Museum, Wellington, 1873: *Mollusca*, 1–37. *Echinodermata*, pp. iv. vii. ix. 1–43; index, 43–48, 38–43. [The plates mentioned in the preface were never published.]

On some Railway Cuttings in the Weka Pass, North Canterbury. [List of Fossils, Mount Brown Beds, Greta (Upper Pareora) Beds.] Trans. N.Z. Inst., xx, 257.

On some Fossils recently obtained from the Cobden Limestone at Greymouth. Trans. N.Z. Inst., xx. 267.

On the Correlations of the "Curiosity-shop Bed" in Canterbury, N.Z., June, 1885. Q.J. Geol. Soc., Nov., 1885. [Long list of fossils, with references.]

On a New Plesiosaur from the Waipara River (*Cimoliosaurus caudalis*). From Bobby's Creek, Waipara. Trans. N.Z. Inst., xxvi, 354–358, pl. xlii. [See also Haast, Geol. of Cant. and Westland, p. 169, and Hector, Trans., vol. vi. p. 341.]

The Pliocene *Mollusca* of N.Z. Macleay Mem. Vol., p. 35, 1893, pls. vi–ix.

On the Relation between the Pareora and the Ahuriri Formations. Trans. N.Z. Inst., ix. 590.

The *Mollusca* of the Pareora and Oamaru Systems of N.Z. Proc. Linn. Soc. N.S.W., 31st March, 1886, vol. i (ser. ii, p. 205). [268 species.]

Sketch of the Geology of New Zealand. Q.J. Geol. Soc., May, 1885, vol. xli, p. 266. [Formations, with lists of characteristic fossils and full references.]

The Wanganui System. Trans. N.Z. Inst., xviii. 336. [Full list of species to date, Aug., 1885.]

Description of some New Tertiary Shells from Wanganui. [Mostly collected by S. H. Drew.] Trans. N.Z. Inst., xv, 410. 1882.

Description of Three New Tertiary Shells in the Otago Museum. [*Cominella striata* and *Zizyphinus hodgei*, Wanganui; *Venus sulcata*, Napier Limestone.] Trans. N.Z. Inst., viii. 383.

Cimoliosaurus caudalis, n. sp. (abstract). Q.J. Geol. Soc., vol. xlix, 1893; Proc., p. 151.

Oxford Chalk *Foraminifera*. N.Z. Jour. Sci., ii. 565.

On the Reptilian Beds of New Zealand. Trans. N.Z. Inst., ix, 581.

On *Crassatellites trailli*. Trans. N.Z. Inst., xxxviii. 65.

On *Conchothyra parasitica*. Trans. N.Z. Inst., xxvi. 358, pl. xliii. [See also a poor figure, upside down, fig. 20, p. 58, Cat. N.Z. Court Indian and Colonial Ex., 1886. Name spelled incorrectly.]

Description of some New Tertiary *Mollusca* from Canterbury, and 68 Species from White Rock, Mount Harris, and Waihao. Trans. N.Z. Inst., ix, 593, pl. xvi [13 sp. fig.].

On a Trilobite from Reefton. Proc. Linn. Soc. N.S.W., ser. ii, vol. ii, p. 257.

Karrer, Felix.

Die Foraminiferen-Fauna des tertiaren Grunsandsteines der Orakei-Bay bei Auckland. Mit 1 Tafel, xvi (69–86), Pal. Voy. "Novara." 1864.

Kidston, R., and Gwynne-Vaughan, D. T.

On the Fossil *Osmundaceæ* (*O. dunlopi* and *O. gibbiana*), New Zealand new species from Jurassic rocks near Gore. Trans. Roy. Soc. Ed., vol. xlv, pt. 3, p. 759, 1907; vol. xlvi, pt. 2, p. 213, 1909; vol. xlvi, pt. 3, p. 651, 1909.

Kirk, T. W.

Description of New Tertiary Fossils. Trans. N.Z. Inst., xiv, 409.

Knight, Charles.

On the Teeth of the Leiodon. Trans. N.Z. Inst., vi. 358, pls. xxiv–xxvi; 1874. Pl. xxiv—figs. A–F, *Leiodon haumuriensis*, Hector; fig. G, *Mauisaurus* (tooth ?): fig. H, tooth of *Plesiosaurus traversii*. Pl. xxv, *Leiodon*. Pl. xxvi, *Taniwhasaurus* (?).

Lydekker, R.

Cat. Fossil *Reptilia* in the British Museum, vol. ii. [P. 113, *Ichthyosaurus hectori*, Lydd., I., Australia: Hector, T., vi, p. 355: p. 118, *Cimoliosaurus tenuis*, Hector, Trans. N.Z. Inst., vi, 345; 1874: p. 216, *Cimoliosaurus haasti*, Hector, Trans. N.Z. Inst., vi, 346: p. 220, *Cimoliosaurus australis*, Owen. Rep. B.A., 1861, Trans. of Sec., p. 122; 1862 (*Leiodon, Squalodon, Zeuglodon*): p. 245, *Cimoliosaurus hoodi*, Owen, Geol. Mag., Dec. i, vol. vii, 53 (1870), plesiosaur: p. 247, *Plesiosaurus holmesi*, Hector, Trans. N.Z. Inst., vi, 344: *Plesiosaurus traversi*, Hector, Trans. N.Z. Inst., vi, p. 345: *Plesiosaurus mackayi*, Hector, Trans. N.Z. Inst., vi, 345: *Mauisaurus latibranchialis*, Hector, Trans. N.Z. Inst., vi, 350.]

McKay, A.

Mataura Plant Beds. Rep. N.Z. Geol. Surv., No. 13, 1879–80, p. 39.

Fossils from West Coast of South Island. Rep. N.Z. Geol. Surv., No. 8, 1873–74, p. 74.

Fossils from Hokonui District. Rep. N.Z. Geol. Surv., No. 11, 1877–78, p. 49.

Fossils from Mount Potts. Rep. N.Z. Geol. Surv., No. 11, 1877–78, p. 91.

Reports relative to Collection of Fossils in South-east District of Otago: Caversham to Catlin's River. Rep. N.Z. Geol. Surv., 59; 1872–73.

Reports relative to Collection of Fossils made in East Cape District, North Island. Rep. N.Z. Geol. Surv., 116; 1872–73.

On the Reptilian Beds of New Zealand. Trans. N.Z. Inst., ix, 581.

Curiosity-shop, Rakaia River, Canterbury: Notes to accompany a Collection of Fossils from that Locality. Rep. N.Z. Geol. Surv., 75; 1879–80.

On the Genus *Rhynchonella*. Trans. N.Z. Inst., xiii, 396.

On a Diatom Deposit near Pakaraka, Bay of Islands. Trans. N.Z. Inst., xxiii, 375, and xxv, 375.

Marshall, P.

Some New Zealand Fossil Cephalopods. Trans. N.Z. Inst., xli, 143.

Montgomery, A.

Some Fossil Plants in Quartzite at Pukeiau, Southland. N.Z. Jour. Sci., vol. i, 1882, p. 141.

Murdoch, R.

Description of some New Species of Pliocene *Mollusca* from the Wanganui District, with Notes on other Described Species. Trans. N.Z. Inst., xxxii, 216.

Newton, E. Tully.

On two Chimæroid Jaws from the Lower Greensand of New Zealand, June 7, 1876. Q.J. Geol. Soc., vol. xxxii, p. 326; 1876 (No. 127). [*Ischyodus brevirostris*, Agassiz, pl. xxi, figs. 1–5; *Callorhynchus hectori*, Newton, sp. nov., figs. 6–9.]

Owen, Professor.

Notice of some Saurian Fossils discovered by J. H. Hood, Esq., at Waipara, Middle Island. N.Z. [*Plesiosaurus hoodii*, Owen; *P. crassi costatus*. Owen.] Geol. Mag.. 68, Feb. 1870. vol. vii, pl. iii.

On Reptilian Fossils discovered by Mr. Cockburn Hood in New Zealand. Brit. Assoc. Rep., 1861. p. 122.

Park. James.

On the Older Fossiliferous Rocks in Nelson. Rep. Geol. Explor. N.Z., 1885. p. 178. [Deals mainly with fossils from Silurian rocks at Baton River. a list of which is given—mostly brachiopods.]

On the Geology of Western Portion of Wellington Province and Part of Taranaki. Rep. N.Z. Geol. Surv., 1886–87, p. 24. [Gives extensive lists of Pliocene fossils from localities around Wanganui, and Waitotara.]

Marine Tertiaries of Otago and Canterbury: [Extensive Lists of Fossils.] Trans. N.Z. Inst., xxxvii, 489.

Description of a New Species of *Pecten* from the Oamaru Series [*P.* (*Pseudamussium*) *Huttoni*—both valves smooth.] Trans. N.Z. Inst., xxxvii, 485.

Purnell. C. W.

On the Wanganui Tertiaries. Trans. N.Z. Inst., vii, 453.

Shakespear, Ethel M.R., D.Sc.

On some New Zealand Graptolites. Geol. Mag., n.s., dec. v, vol. v, No. 4, April 1908. p. 145.

Stache. Dr. Guido.

Die Foraminiferen der tertiaren Mergel des Whangaroa Hafnes (Prov. Auckland), Raglan. Mit 4 Tafeln, xxi–xxiv (159–304) Pal. Voy. "Novara," 1864.

Stoliczka, Dr. Ferdinand.

Fossil Bryozen aus dem tertiaren Grunsandsteine der Orakei-Bay bei Auckland. Mit 4 Tafeln, xvii–xx (87–158) Pal. Voy. "Novara," 1864.

Tate, Ralph.

On New Species of *Belemnites* and *Salenia* from the Middle Tertiaries of South Australia. Q.J. Geol. Soc., vol. xxxiii, p. 257, No. 130; 1877. [*Belemnites* (*Graphularia*) *senescens*, n.s., fig. 1 (wood-cut). Also found in Oamaru and Kakanui beds. See Rep. N.Z. Geol. Surv., 1881, p. xxix.]

Tenison-Woods, Rev. J. E.

Palæontology of New Zealand, pt. iv [parts i, ii, and iii were never published]: Corals and *Bryozoa* of the Neozoic Period in New Zealand. Wellington, 1880. Pp. preface, i–v. 1–32. [3 plates (not numbered). 32 figs. This describes only the specimens exhibited in the N.Z. Court of the Sydney Exhibition.]

Thomson, J. Allan.

Fossils from Kakanui. [Three new species.] Trans. N.Z. Inst., xl, 98, pl. xiv.

Traill, Charles.

On the Tertiary Series of Oamaru and Moeraki. Trans. N.Z. Inst., ii, 166.

Unger, Dr. Franz.

Fossile Pflanzenreste. Mit 5 Tafeln, pp. 1–3, Pal. Voy. "Novara," Geol. Theil, I Bd., 2 Ab., pp. 1–13.

Vine, G. R., jun. (Hamilton, A.).
On the *Foraminifera* of the Tertiary Beds at Petane, near Napier. Trans. N.Z. Inst., xiii, 393.

Waters, Arthur William.
On Tertiary Cyclostomatous *Bryozoa* from New Zealand. Q.J. Geol. Soc., vol. xliii, 1887, p. 337, pl. xviii.
On Tertiary Chilostomatous *Bryozoa* from New Zealand. Q.J. Geol. Soc., 1887, vol. xliii, p. 40, pls. vi–viii.

Woodward, Henry.
On a New Fossil Crab from the Tertiary of New Zealand, collected by Dr. Hector (with a note by Dr. Hector). Q.J. Geol. Soc., vol. xxxii, p. 51, pl. vii; 1875. [*Harpactocarcinus tumidus*. Rep. N.Z. Geol. Surv., 1873–74, p. 111.]

Zittel, Dr. Karl A.
Fossile Mollusken und Echinodermen (N.Z.). Mit 10 Tafeln, vi-xv, 15–68, Pal. Voy. "Novara." 1864.
Fossile Mollusken und Echinodermen aus Neu-seeland; nebst Beitragen von Herrn Bergrath Fr. Ritter von Hauer und Prof. E. Suess. 10 Plates. See Geol. Mag., vol. i, p. 73; 1864.

Zittel, Count M.
General Notes from Proc. Imp. Geol. Instit., Vienna, Jan. 20, 1863.
On Hochstetter's Collection. See Q.J. Geol. Soc., 1863, vol. xix, pt. ii, p. 20.

ART. IX.—*Notes on New Zealand* Lepidoptera.

By E. MEYRICK, B.A., F.R.S.

Communicated by G. V. Hudson, F.E.S.

[*Read before the Wellington Philosophical Society, 5th May, 1909.*]

CARADRINIDÆ.

Melanchra decorata, Philp.

Mr. Philpott has sent me a ♀ of this species, with the request that I would describe it, as his description was taken from a faded specimen, and is therefore in some respects defective.

40 mm. Head mixed with whitish, olive-yellowish, pale-greenish, pale-crimson, and dark-fuscous colouring. Palpi ochreous-whitish irrorated with crimson, second joint with a streak of black irroration. Thorax with strong anterior bifid crest, light pinkish-ochreous streaked and on collar barred with blackish and light-greenish. Forewings pale ochreous suffused with light olive-greenish; veins more or less marked with fine interrupted black lines; first and second lines double, very indistinct, darker greenish, waved, forming pairs of small blackish spots on costa, second strongly retracted near costa so as to be parallel to costa for some distance; median line dark

fuscous, angulated near costa, on costa blackish; orbicular and reniform finely outlined with black. orbicular rather large, suboval, oblique, reniform large, transverse-oval, pale whitish-rosy: a broad irregular dark-fuscous streak above fold from base to termen, including a strong black line along fold, edged beneath by an irregular streak of white suffusion from before middle to subterminal line, on which it is bent upwards for a short distance; subterminal line otherwise faintly indicated, pale, waved, traversing an oblique dark reddish-fuscous suffused streak above middle: cilia pale ochreous, suffused with greenish and barred with fuscous. Hindwings rather dark grey, tinged with pinkish, with suffused darker grey discal spot and terminal band: cilia light greyish-ochreous, with a greenish-fuscous shade.

A distinct species.

I have been asked to express an opinion on the classification adopted by Sir George Hampson in his "British Museum Catalogue" for this family, so far as it relates to New Zealand species. The matter cannot be discussed in detail without entering on a general survey of other faunas; but, speaking generally, I may say that I see no reason at present to alter my previous views as to the limits and constitution of the New Zealand genera. I should not recommend any student of the group to adopt the generic divisions employed by Sir George Hampson unless he finds that he can in practice always clearly distinguish these genera by the structural characters employed, and also finds that these genera appear to him truly natural—that is, such that the species in each genus are more closely allied together through inheritance of common characters than they are to the species of any other genus. I do not myself find this, and am therefore at present unable to adopt his classification, which appears to me to conflict with geographical distribution, instead of explaining it.

CRAMBIDÆ.

Crambus thrincodes, n. sp.

♂. 28 mm. Head white, with a light ochreous spot behind eye. Labial palpi fuscous, basal joint white. Maxillary palpi white, towards base dark fuscous. Antennæ white, beneath brownish-ochreous. Thorax white, patagia suffused with pale ochreous and sprinkled with dark fuscous. Abdomen whitish-ochreous tinged with yellow. Forewings elongate, very narrow, gradually dilated, costa slightly arched, apex obtuse, termen slightly rounded, oblique; light ochreous-brownish, veins sprinkled with dark fuscous; a broad white costal streak, suffused beneath, enclosing a narrow blackish costal streak from base almost to apex, which is divided into three portions by rather broad interruptions of white before middle and at ¾ (representing origin of first and second lines): on lower margin of the white streak are a longitudinal projection at base, and an inwards-oblique projection representing first line, space between and beyond these to near middle suffused with blackish; beyond this a suffused white streak in disc to ¾, between which and costal streak is enclosed a round white discal spot at ⅔ edged with dark fuscous and centred with a fuscous dot; second line from costal streak to dorsum before tornus white, sharply dentate, indented near dorsum: cilia light brownish, partially barred with white. Hindwings whitish-ochreous; a small spot of grey suffusion on costa before apex; cilia ochreous-whitish.

Kaitoke; one specimen received from Mr. G. V. Hudson. This remarkable and very distinct species is intermediate in character between *flexuosellus*, *tuhualis*, and *cyclopicus*, partaking nearly equally of the characters of all three; it is probably very local.

TORTRICIDÆ.

Cacœcia acrocausta, Meyr.

Additional specimens sent by Mr. A. Philpott show the variation of colouring to be very considerable; one ♂ is very uniformly coloured, forewings light brownish, with two or three black scales, costal extremity of central fascia and costal patch indicated by two very small darker spots, hindwings whitish-grey; three females are whitish-ochreous more or less strongly tinged with yellow, with well-marked small yellow-brown or dark fuscous spots on costa in middle and at $\frac{3}{4}$, and sometimes one at $\frac{1}{5}$, dorsal extremities of basal patch and central fascia and sometimes intervening space clouded with brown, hindwings ochreous-whitish. The species is, however, always recognisable by the form of wing and palpi, the dark patch in apical cilia (least conspicuous in the ♂ mentioned above), and stalking of 6 and 7 of hindwings.

PHALONIADÆ.

Heterocrossa adreptella, Walk.

A ♂ sent by Mr. A. Philpott has a streak of blackish suffusion along fold throughout, and another rising from this near base and traversing disc to $\frac{3}{5}$.

ŒCOPHORIDÆ.

Borkhausenia paratrimma, n. sp.

♂. 15 mm. Head and thorax ferruginous-ochreous. Palpi ochreous irrorated with dark fuscous. Antennæ dark grey. Abdomen grey. Forewings elongate, rather narrow, costa moderately arched, apex round-pointed, termen very obliquely rounded; ferruginous-ochreous; very indistinct oblique fasciæ of fuscous irroration before and beyond middle; some slight fuscous irroration towards apex: cilia ferruginous-ochreous. Hindwings and cilia grey.

Invercargill, in December; two specimens received from Mr. A. Philpott. Allied to *B. siderodeta*, but certainly distinct, being rather broader-winged; differs by absence of dark fuscous irroration in forewings, and grey, not dark fuscous, hindwings.

Borkhausenia amnopis, n. sp.

♀. 16–18 mm. Head whitish-ochreous, sides of face sprinkled with grey. Palpi whitish-ochreous irrorated with dark fuscous, apex of joints whitish. Antennæ dark grey ringed with white, alternate rings wider. Thorax whitish-ochreous irrorated with dark fuscous. Abdomen dark grey, segmental margins white. Forewings elongate, costa moderately arched, apex round-pointed, termen almost straight, very oblique; whitish-ochreous, irregularly mixed with whitish and pale ferruginous-ochreous, and irrorated throughout with grey; a short oblique blackish streak representing plical stigma; first discal stigma moderate, round, blackish, beyond plical; second discal larger, round, fuscous or dark fuscous, edged with black, connected with tornus by a patch of fuscous suffusion; a curved black irregular subterminal line, indented near costa and sinuate above dorsum, more or less edged with white anteriorly; some fine blackish irroration towards costa before and beyond middle: cilia whitish-ochreous, more or less sprinkled with dark fuscous, especially on a tornal patch, beneath which is an ochreous-whitish patch. Hindwings grey; cilia pale grey, with grey subbasal shade.

Invercargill, from November to March; two specimens received from Mr. A. Philpott. Allied to *contextella*, but somewhat broader-winged, and distinguished by the general grey irroration, black subterminal line, which is placed so that costal extremity is nearer apex, and grey hindwings.

Zirosaris, n. g.

Head with appressed hairs: ocelli present; tongue developed. Antennæ $\frac{3}{4}$, in ♂ shortly ciliated ($\frac{2}{3}$), basal joint moderate, without pecten. Labial palpi long, recurved, second joint beneath with dense long rough projecting scales throughout, terminal joint shorter than second, slender, acute. Maxillary palpi rudimentary. Thorax with small posterior crest. Posterior tibiæ clothed with hairs above. Forewings with tufts of scales on surface; 2 nearly from angle, 7 and 8 stalked, 7 to apex, 11 from middle. Hindwings 1, elongate-ovate, cilia $\frac{1}{2}$; 3 and 4 connate, 5–7 parallel.

Allied to *Trachypepla*, but with quite different palpi.

Zirosaris amorbas, n. sp.

♂. 19 mm. Head and thorax blackish, finely sprinkled with grey-whitish. Palpi blackish, second joint finely sprinkled with whitish, terminal joint with two oblique whitish lines. Antennæ blackish, finely dotted with white. Abdomen dark fuscous, segmental margins white. Forewings elongate, rather narrow, costa gently arched, apex rounded, termen obliquely rounded; dark purplish-fuscous mixed with blackish; basal area, an undefined spot on middle of costa, and four diminishing spots on costa posteriorly finely sprinkled with whitish: two raised tufts containing a few brownish-ochreous scales transversely placed in disc at about $\frac{1}{3}$; stigmata formed by raised black tufts, plical beneath first discal, second discal transverse, edged with white posteriorly, above the two discal stigmata are a few pale brownish-ochreous scales; a curved posterior line of whitish irroration indistinctly indicated: cilia dark grey with some white points and a blackish-grey shade. Hindwings dark fuscous, towards apex irrorated with blackish; cilia fuscous, with blackish subbasal shade.

Broken River, Canterbury; one specimen collected by Mr. J. H. Lewis, received through Mr. A. Philpott.

ART. X.—Lepidoptera *from the Kermadec Islands.*

By E. MEYRICK, B.A., F.R.S.

Communicated by G. V. Hudson, F.E.S.

[*Read before the Wellington Philosophical Society, 6th October*, 1909.]

IN the following complete list of *Lepidoptera* taken, those species marked with an asterisk were identified by Mr. Hudson and not seen by me; of the rest, examples were forwarded to me for identification. I will begin by summarising the geographical relations of this portion of the fauna. and then give a systematic list of the species.

The total number of species is 46. Of this number, 24 are common insects of wide general distribution, which, owing to their numerical abundance. powers of flight, and adaptation to food-plants of common occurrence, have found their way to suitable stations throughout a more or less large area of the warmer regions of the globe, though one or two of them may be sometimes transported by man: these 24 may be disregarded. It may be noticed that 14 of these have not yet occurred in New Zealand; probably some will still be found there as stragglers, but in general the New Zealand climate is too temperate for them or their food-plants.

Of the remaining 22 species, 4 occur also in New Zealand and Australia (one of these, *Monopis ethelella*, being semi-domestic, and recently found also in South Africa), 6 occur in New Zealand only, 1 in Australia only, 3 in other Pacific islands, and 8 are at present only known as endemic. Since, however, the *Lepidoptera* of the Pacific islands are very little known, it is highly likely that some at least of these species will be found hereafter amongst other groups of these islands. Of the 8 endemic species, 2 are probably to be regarded as of New Zealand type, 3 of Pacific, and 3 of Australian, but it is quite possible that the 3 last may prove also to have Pacific representatives. In the present state of our knowledge I should think that the above facts indicated that the islands have always been considerably isolated, and have received their lepidopterous fauna by the accidental immigration, across a wide stretch of sea, of specimens carried by strong winds.

In the following list of species the number of specimens taken is mentioned in each case; the full geographical distribution of each species is given; and the food-plant of the larva is mentioned whenever known, as it must always be taken into account as a factor in distribution :—

ARCTIADÆ.

*** Nyctemera annulata, Boisd.**

12 specimens. New Zealand. Larva on *Senecio.*

*** Utetheisa pulchella, L.**

10 specimens. Europe, Asia, Africa. Australia, Pacific islands, New Zealand. Larva on grasses, &c.

CARADRINIDÆ.

Leucania loreyi, Dup.

3 specimens. Southern Europe, southern Asia, Africa, Australia, Fiji.

* **Leucania unipuncta**, Hw.

7 specimens. North and South America, Europe, Asia, Australia, New Zealand. Larva on grasses.

Tiracola plagiata, Walk.

5 specimens. Central America, India, Malay Islands, Australia, Pacific islands. Larva on *Emilia*.

* **Heliothis armigera**, Hb.

5 specimens. North and South America, Europe, Asia, Africa, Australia, Pacific islands, New Zealand. Larva on many vegetables and other plants.

* **Agrotis ypsilon**, Rott.

2 specimens. North and South America, Europe, Asia, Africa, Australia, New Zealand. Larva on many plants.

Caradrina reclusa, Walk.

11 specimens. India. Malay Islands, New Guinea, Fiji.

Spodoptera littoralis, Boisd.

18 specimens. Southern Europe, Asia. Africa, Australia, Pacific islands. Larva on *Lantana*.

Eriopus Maillardi, Gn.

8 specimens. Africa, southern Asia, New Guinea, Pacific islands.

Perigea capensis, Gn.

14 specimens. Africa, Asia, Australia, Pacific islands. Larva on *Acanthaceæ*.

PLUSIADÆ.

Hydrillodes surata, n. sp.

♂ ♀. 33–34 mm. Head, palpi, and thorax in ♂ dark fuscous, in ♀ ochreous-fuscous; palpi in ♂ rectangularly bent at both joints, very densely clothed with rather rough scales throughout except tip of terminal joint, especially largely towards apex of second joint, which much exceeds crown, terminal joint as long as second, in ♀ recurved, sickle-shaped, first two joints densely scaled, terminal joint $\frac{1}{5}$ of second, with appressed scales, posteriorly with loosely projecting hairs throughout, apex pointed. Anterior legs in ♂ with hairs of coxæ forming a strong apical brush, femora short, unevenly swollen, beneath with dense rough projecting hairs longest at apex, tibiæ swollen, beneath with dense rough projecting hairs throughout, middle and posterior femora in ♂ beneath with rough projecting hairs diminishing to apex. Forewings elongate-triangular, apex rounded, termen rounded, slightly waved, somewhat oblique; dark fuscous, in ♀ suffused with light brownish-ochreous from base to second line; first and second lines in ♂ hardly paler, in ♀ pale ochreous, edged with dark fuscous, slightly waved, first almost straight, second little beyond middle, curved on upper $\frac{2}{3}$; a dark-fuscous transverse-linear discal mark between them; subterminal line represented by an irregular series of whitish-ochreous dots connected by dark suffusion; cilia rather dark fuscous. Hindwings light fuscous, with faint darker postmedian shade; cilia whitish-fuscous.

2 specimens; 9 others taken. There are three examples of the same species in the British Museum from the Solomon Islands; it will probably be found widely distributed in the Pacific islands. The species is nearly allied to the common Indian and Australian *H. lentalis*, Gn., but larger, and certainly distinct by the structural characters of palpi and legs.

Hypenodes costæstrigalis, Stph. (*exsularis*, Meyr.).

2 specimens. Europe, Australia, New Zealand. A closely allied form occurs in the Hawaiian Islands.

Hypena gonospilalis, Walk.

13 specimens. Java, Pacific islands.

Thermesia rubricans, Boisd.

2 specimens. Africa, southern Asia, Pacific islands.

* Plusia chalcites, Esp.

4 specimens. North and South America, southern Europe, Africa, southern Asia, Australia, Pacific islands. Larva on various plants.

* Achæa melicerte, Drury.

1 specimen. Africa, Asia, Australia, Pacific islands, New Zealand.

HYDRIOMENIDÆ.

Phrissogonus laticostatus, Walk.

1 ♂, 1 ♀. Australia.

Phrissogonus denotatus, Walk.

3 specimens. Australia, New Zealand. Larva on *Brachyglottis repanda.*

* Chloroclystis indicataria, Walk.

1 specimen. New Zealand.

Hydriomena officiosa, n. sp.

♀. 25 mm. Head and thorax brownish mixed with pale ochreous, face with moderate tuft, thorax with two dark-grey bars. Palpi moderate, dark fuscous, base of second and third joints whitish. Forewings triangular, termen almost straight, slightly waved, rather oblique; brownish, irrorated with blackish and whitish, with almost straight, somewhat waved, dark-fuscous striæ; edge of basal patch slightly whitish-margined, angulated near costa; edges of median band somewhat black-marked, whitish-margined, posterior above middle with a slight distinctly black-marked sinuation, followed by a small patch of undefined pale-ochreous suffusion; discal dot linear, blackish; subterminal line waved, slender, whitish. Hindwings with termen rounded, waved; grey, towards dorsum with dark-fuscous and whitish striæ.

1 specimen; 5 others taken. Nearest to the New Zealand *H. deltoidata*, but easily distinguished by the smaller size and grey hindwings.

* Euchœca rubropunctaria, Dbld.

1 specimen, in very poor condition. Australia, New Zealand. Larva on *Haloragis alata.*

STERRHIDÆ.

* **Leptomeris rubraria**, Dbld.

17 specimens. Australia, New Zealand.

NYMPHALIDÆ.

***Anosia bolina**, L.

1 ♂ specimen. India, Malay Islands, Australia, Pacific islands, New Zealand.

* **Vanessa itea**, F.

3 specimens. Australia, Norfolk Island, New Zealand.

SATYRIDÆ.

* **Melanitis leda**, L.

1 specimen. Africa, southern Asia, Australia, Pacific islands.

PHYCITIDÆ.

Homœosoma anaspila, Meyr.

8 specimens. New Zealand.

PYRAUSTIDÆ.

Eranistis, n. g.

Face rather oblique; ocelli present; tongue developed. Antennæ ¾. Labial palpi moderate, ascending, second joint dilated with rough projecting scales, tufted towards apex beneath, terminal joint very short, loosely scaled. Maxillary palpi moderate, porrected, loosely scaled. Forewings with 3 almost from angle, 4 and 5 stalked, 7 out of 8 near base, 9 and 10 out of 8 beyond 7, 11 almost connate with 8. Hindwings 1; frenulum in ♀ simple; 4 and 5 stalked, 7 out of 6 near origin, anastomosing with 8 to middle.

This curious genus differs from all others in the *Pyraustidæ* by the origin of vein 7 of the forewings from 8; it does, notwithstanding, belong here, and not to the *Pyralididæ*, and is an instance of the independent and exceptional acquisition of a character which is normally characteristic of another family. It is undoubtedly allied to the group of *Nymphula* and *Perisyntrocha*; the simple frenulum of ♀ is an interesting and unusual character, but found in some species of that group.

Eranistis pandora, n. sp.

♀. 22 mm. Head and thorax light brownish-ochreous. Labial palpi light brownish-ochreous sprinkled with dark fuscous, white towards base beneath. tip white. Maxillary palpi pale ochreous banded with blackish. Abdomen ochreous-whitish. Forewings elongate-triangular, costa moderately arched towards apex, apex obtuse, termen obliquely bowed; brownish-ochreous, thinly sprinkled with dark fuscous; costa suffused with dark-fuscous irroration towards base; lines represented by very undefined thick shades of dark-fuscous irroration, first about ¼, slightly curved, second about ¾, nearly parallel to termen, space beyond this more irrorated with dark fuscous. Hindwings ochreous-white. Undersurface of forewings and hindwings suffusedly whitish, with a bent dark-grey post-median line becoming obsolete dorsally.

1 specimen; another taken. The example described is in indifferent condition, but is so distinct as to be easy of recognition.

Dracænura ægialitis, n. sp.

♂. 26 mm. Head and thorax pale whitish-ochreous, face fuscous, shoulders suffused with fuscous. Palpi dark fuscous, white towards base beneath. Antennæ whitish-ochreous. Abdomen whitish-ochreous, segmental margins whitish. Forewings elongate-triangular, costa posteriorly moderately arched, apex obtuse, termen gently rounded, oblique; pale greyish-ochreous, slightly tinged with fuscous; costa suffused with fuscous towards base; lines thick, suffused, fuscous, first from ⅕ of costa to ⅓ of dorsum, slightly curved, second just before ¾, nearly parallel to termen, slightly indented beneath costa and on fold; roundish orbicular and transverse discal spots fuscous; cilia pale greyish-ochreous. Hindwings with termen rounded; whitish; a thick grey nearly straight slightly waved postmedian line; a moderate suffused greyish-ochreous terminal fascia, towards termen fuscous-tinged; cilia pale greyish-ochreous, tips whitish.

1 specimen; 5 others taken. A true *Dracænura* in all respects, with the peculiar neuration of hindwings in ♂; perhaps nearest *pelochra*, but quite different in colour. The genus *Dracænura* is characteristic of the South Pacific islands, where it is probably rather extensive.

Diasemia ramburialis, Dup.

9 specimens. North and South America, Europe, Asia, Africa, Australia, Pacific islands.

Hymenia fascialis, Cr. (*recurvalis*, F.).

13 specimens. Central and South America, Africa, southern Asia, Australia, Pacific islands.

Scoparia fragosa, n. sp.

♀. 13 mm. Head and thorax whitish-ochreous, mixed with white, patagia mixed with dark fuscous. Palpi 2½, fuscous, upper margin white. Abdomen pale ochreous. Forewings elongate, rather narrow, posteriorly dilated, costa slightly arched, apex obtuse, termen slightly rounded, oblique; fuscous suffusedly mixed with whitish, with scattered black scales; a blackish streak from base of costa to disc beyond ⅓, interrupted beneath costa; lines cloudy, white, confused with the general whitish suffusion, first irregularly dentate, edged with blackish towards costa posteriorly, second unusually approximated to termen, acutely angulated, indented above angle; orbicular and claviform elongate, blackish, resting on first line, claviform edged beneath with whitish-ochreous suffusion; discal mark elongate-X-shaped, blackish, edged beneath with whitish-ochreous; a blackish costal spot above this; subterminal line obsolete; cilia whitish, basal half barred with fuscous (imperfect). Hindwings grey-whitish; cilia whitish.

1 specimen. Denham Bay, Sunday Island. Not very near to any New Zealand or Australian species; on a careful comparison it is perhaps nearest to the Hawaiian *S. catactis*, Meyr., and is decidedly of general Hawaiian type.

PYRALIDIDÆ.

Endotricha mesenterialis, Walk.

12 specimens. Southern Asia, Australia, Pacific islands.

PTEROPHORIDÆ.

Sphenarches caffer, Z.

2 specimens. Africa, southern Asia, Australia, Pacific islands.

TORTRICIDÆ.

Capua semiferana, Walk.

3 specimens. New Zealand.

EUCOSMIDÆ.

Spilonota melanotreta, n. sp.

♀. 22 mm. Head, palpi, and thorax rather dark fuscous mixed with whitish, patagia tinged with brownish. Abdomen dark grey. Forewings elongate, rather narrow, posteriorly slightly dilated, costa gently arched, apex obtuse, termen gently rounded, oblique; brownish, suffusedly mixed with grey-whitish, and sprinkled with dark fuscous; costa with oblique alternate long and short dark strigulæ; an irregular streak of blackish suffusion along basal third of dorsum; an irregular streak of dark-brown suffusion mixed with blackish along submedian fold from base to middle, and a similar longitudinal streak in disc from ⅓ to ¾, connected posteriorly with an elongate blackish spot above middle nearly reaching termen; a very small irregular black apical spot; three or four minute black dots towards termen on lower half, and three or four others on central third of termen; cilia fuscous, with rows of whitish points edged anteriorly with blackish. Hindwings with 3 and 4 long-stalked; grey, on veins and towards termen suffused with dark fuscous; cilia grey-whitish, with fuscous subbasal shade.

1 specimen; 8 others taken.

* **Bactra noteraula,** Wals. (*straminea,* Meyr.).

1 specimen. New Zealand.

Polychrosis meliscia, n. sp.

♀. 18 mm. Head, palpi, and thorax whitish-ochreous, second joint of palpi finely sprinkled with dark fuscous towards middle. Forewings elongate, posteriorly dilated, costa gently arched, apex obtuse, termen gently rounded, oblique; 2 from ¾ of cell; whitish-ochreous finely speckled with dark fuscous, and irregularly strewn with small ferruginous-ochreous strigulæ; markings faint, indefinite, formed by greater development of dark speckling and strigulation; a moderate basal patch, outer edge nearly straight, rather oblique; central fascia indicated by a broad costal blotch reaching half across wing and a patch before tornus; cilia whitish-ochreous, obscurely barred with ferruginous-ochreous. Hindwings grey-whitish, posteriorly faintly strigulated with grey; cilia whitish.

1 specimen; 1 other taken.

COSMOPTERYGIDÆ.

Stagmatophora ællotricha, Meyr.

2 specimens. New Zealand.

Pachyrhabda antinoma, n. sp.

♂. 9 mm. Head, palpi, antennæ, thorax, and legs silvery-white, terminal joint of palpi with anterior edge dark fuscous; antennæ greyish beneath; anterior legs suffused with dark fuscous, posterior tibiæ with a small blackish apical spot above. Abdomen light yellowish, on sides and beneath silvery-white. Forewings narrowly elongate-lanceolate; silvery-whitish, faintly ochreous-tinged; extreme costal edge dark grey on basal half; cilia ochreous-whitish. Hindwings grey-whitish; cilia whitish. Undersurface of forewings suffused with dark grey.

1 specimen, taken in July.

GRACILARIADÆ.

Gracilaria octopunctata, Turn.

6 specimens. India, Australia.

PLUTELLIDÆ.

Glyphipteryx scolias, n. sp.

♀. 8 mm. Head and thorax light greyish-bronze. Palpi with four whorls of blackish white-tipped scales, without tuft. Antennæ bronzy-fuscous. (Abdomen broken.) Forewings elongate, costa gently arched, apex acute, termen extremely obliquely rounded; 7 and 8 stalked; greyish-bronze; six whitish costal streaks edged anteriorly with dark-fuscous suffusion, first from middle, oblique, reaching half across wing, second at ¾, equally long, less oblique, third short, cloudy, and less defined, remaining three short, direct, close together before apex; an irregularly sinuate slender silvery-whitish oblique streak from dorsum before tornus, nearly reaching apex of second costal; a silvery-whitish dot on middle of termen; a round black apical dot; cilia bronzy-whitish, with a black subbasal shade, interrupted with whitish below apex, with a fine black line projecting from interruption, above apex with a black hook, and with four fine black bars in costal cilia between streaks. (Hindwings missing.)

1 specimen. Denham Bay. Very nearly allied to *G. iochœra* from New Zealand, but that species is larger, and has the prætornal streak straight, and the terminal silvery-whitish dot replaced by a short streak. I have a good series of it, and these characters are constant.

Plutella maculipennis, Curt.

6 specimens. Quite cosmopolitan. Larva on cabbage, turnip, and other *Cruciferæ*.

TINEIDÆ.

Opogona aurisquamosa, Butl.

2 specimens; 21 others taken. Hawaiian and South Pacific isles. Larva on sugar-cane and banana.

Decadarchis flavistriata, Wals.

1 specimen; 2 others taken. Hawaiian Isles. The example examined differs from the description and figure of the single original type in having a black dot representing plical stigma, and the streak at base of costal cilia towards apex blackish. I do not think, however, that it can be separated specifically. Hindwings with 5 and 6 stalked, 6 to costa.

* **Monopis ethelella**, Newm.

3 specimens. Australia, New Zealand, South Africa. A semi-domestic species, of which the larva probably feeds on refuse.

ART. XI.—*Early History of Rangitikei, and Notes on the Ngati Apa Tribe.*

By T. W. DOWNES.

[*Read before the Wellington Philosophical Society, 6th October, 1909.*]

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PLATE X.—Sketch-map from very old Maori sketches, showing early occupation of lower Whanga-ehu and Turakina Valleys by Ngati Apa people.

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CHAPTER I.

IT has been my good fortune to have the curtain of obscurity of the long-ago past slightly drawn aside for me, and so to gain a glance into the dim and fast-fading history of our Island at a time when it was to us an enchanted, dreamlike land.

Few people have had so much written about them, in so comparatively few years, too, as the Natives of New Zealand; but there is something fascinating in the old Maori who sits half-dreaming, conjuring up those other days when fighting and feasting were almost all that was worth living for, and telling us of them in stories handed down by his forefathers.

The history of the old-time Maori wars—*i.e.*, of Maori with Maori—is a subject comparatively unknown, for, apart from the "Journal of the Polynesian Society," little has been published regarding it, and of this particular tribe we have no printed records at all. This paper is little more than a collection of scattered fragments, gathered with much labour and patience. Everything pertaining to the olden days—"the good old Maori days"—has become most difficult to learn, and soon all opportunity will be lost, for the old men with their stores of knowledge are almost gone, and in a few more years at most will have passed through Reinga's gate.

I had hoped that the task of delving into the old history of this district might be undertaken by others who, I am confident, have a deeper knowledge of Maori lore, and are therefore better qualified to handle a difficult subject. However, I trust the following notes will prove interesting to some at least who, like the author, have lived all their days in Maoriland, this "sea-girt Eldorado of the south."

The district inhabited in former times, and to some extent even yet, by the Ngati Apa tribes was roughly all the country drained by the Whanga-ehu, Turakina, and Rangi-tikei Rivers, extending as far south as Manawa-tu, and bounded on the north-east by the Ruahine Mountains. A large tract of open and broken forest country about the Moa-whango district called Mokai-Patea was their chief inland home, and Parewa-nui, near the Rangi-tikei River, some eight miles from the sea, was their largest pa. They claim to be descended chiefly from Ruatea, who came to New Zealand in the Kura-haupo canoe about 1350; but all inquiries concerning this ancestor and his great canoe have yielded but little information.

TABLE 1.

1. **Ruatea** **Turi**
2. **Apa-hapai-taketake**
3. **Hapa-tua-rangi**
4. **Taha**
5. **Po-whenua**
6. **Te Rangi-whawhaia**
7. **Papa**
8. **Tau-whiia**
9. **Papa-whenua**
10. **Rangi-powhatu**
11. **Whakamau**
12. **Rangi-mawake**
13. **Putanga**
14. **Ria = Rangi-waho**
15. **Ngana-rangi**
16. **Te Ara-moana**
17. **Ngoio**
18. **Hura = Mehi**
19. **Ria = Hamuera of Parewa-nui (80).**

"Look yonder," said one old man, "behold those distant hills" (pointing to the Ruahine Range). "On those mountains are growing the totara and rimu, the maire and miro trees; but who can tell from this distance what they are? Our forefathers could have told you of these things; we cannot: the haze and mist of time and distance obscure all detail, and our vision cannot pierce the fog. Say, friend, can you tell me of your great navigator Cook, all who were with him, and what they did?" Collapse of questioner, and subject changed.

They were at one time a very strong and numerous people, but they suffered severely at the hands of Te Rau-paraha of the Ngati Toa; and the Ngati Rau-kawa incursions in the early days of the nineteenth century also greatly lessened their power and influence, so that to-day they are but a shadow of their former greatness: but of this later on.

The district mentioned, as well as other parts of New Zealand, seems to have been peopled with a numerous population long before the advent of the fleet in 1350; for when Tamatea visited the district—and to him is credited the honour of being the first to travel inland—he found a numerous people (the descendants of a former and forgotten migration) wherever he went, and if the story of the *taniwha* Tutae-poroporo is to be believed (and who would doubt it!) the Whanga-nui Valley and lower Rangi-tikei districts were thickly populated even in those early times; while the additional evidence of the Ngati Hotu, an aboriginal tribe living round Lake Taupo, helps to prove the presence of people here long before the great migration of 1350 from Hawaiki.

As a full account of the doings of the *taniwha* Tutae-poroporo has already appeared in the Jour. Polynesian Soc., a very brief outline of the legend will be sufficient for the present purpose: Tutae-poroporo was originally a young shark that was caught by a man of the Ngati Apa Tribe named Tu-ariki, who lived at Rangi-tikei.

Ruatea
|
Apa-hapai-taketake
|
Tupoho-ronuku
|
Tamata
|
Tu-ariki.

(Although Tu-ariki is here shown as a Ngati Apa man, the Ngati Apa did not arrive in the Rangi-tikei district till several generations later.) He caught the fish when on a visit to Nelson (Whakatu), and, seeing something special in it, he kept it alive, made a pet of it, and brought it back with him to Rangi-tikei, where he prepared a place for it in the Rangitikei River just where the Tutae-nui Stream joins the river, and here he recited *karakias* over it, and turned it into a *taniwha*. After a time a war-party from Whanga-nui came along, and Tu-ariki was killed, and the *taniwha*, missing his master, started out to look for him. He eventually took up his abode under Taumaha-aute (Shakespeare's cliff), on the Whanga-nui River, and here he devoured the canoes and their crews as they travelled up and down the river. Soon the Whanga-nui people became afraid of the creature, and sought help to be rid of him. They sent to Ao-kehu, of Wai-totara, a celebrated *taniwha*-slayer of eighteen generations back, who devised means of killing the monster by hollowing out a sort of box canoe with a close-fitting lid. He got inside this affair, and floated down-stream past Tutae-poroporo's lair, and as soon as the *taniwha* saw him he rushed out and swallowed both box and Ao-kehu. Thereupon Ao-kehu got out of his box, slashed about with his weapons, cut a way out for himself, and so obtained glory and renown for ever.

To Hau, one of the immigrants in the Aotea canoe (1350), is credited the honour of giving names to the various places along this coast, as embodied in a very old song, a translation of part of which is as follows:—

Then Hau, taking soil of the land in one hand,
Together with the staff of Turoa
(Went forth on his journey giving names)
First he crossed the river, and from its size called it Whanga-nui (great harbour);
Then next he dipped up water, and called it Whanga-ehu (harbour of spray);
Again, he felled a tree to cross, and named it Turakina (throw it down);
Beyond, with long stride, he reached, and named Rangi-tikei (walking with
  long strides);
The next, with doubts as to his power of crossing, he called Manawa-tu (standing
  heart);
Then a whistling wind in his ears gave rise to Hokio,
And the ancient Awa-iti he named after himself, Ohau.
Speechmaking to his followers took place at Otaki.
Etc., etc. —*Translation by S. Percy Smith*

Tamatea is said to have been the captain of the Takitumu canoe; and his journey (according to Utiku Potaka) was somewhat as follows:—

Tamatea was the first person to travel inland from this district. He came from Here-taunga (Hastings), and went first of all to Te Papa-a-Tari-nuku, his son Kahu-ngunu (from whom sprang the Ngati Kahu-ngunu Tribe) accompanying him. Here Tari-nuku gave Tamatea a gift of food, at which his son was very angry, seeing a gift for his father but none for himself, so he left Tamatea and went back to Here-taunga alone. When Tamatea arrived at Puke-o-kahu (a hill north-east of Taihape, about fifteen miles distant) he put a lizard there, and then went on till he came to the waterfall Te Pounga, on the Moa-whango. Here he put some brands from his fire into the waterfall, and it is still called "The Firebrands of Tamatea." Then he journeyed on to Tiki-rere, which drops as a waterfall into the Moa-whango, and there he placed a crayfish. Next he came to Whaka-tara, at Motu-kawa (a hill midway between Tu-ranga-rere and Taihape, about two miles to the east of the road), and there he placed another lizard. Then on he went to Te Whaka-ua, on the south-west portion of the Awa-rua Block, where there is a ridge which he called, after himself, "The Jawbone of Tamatea." Another place he called Harakeke-a-Tamatea (Tamatea's flax). Formerly when strangers went to that place (Whaka-ua) it would rain, but now these things have changed, and the stranger may come or may go without being so heralded.

There was a stone here that had some connection or understanding with the heavens above, for whenever the Natives journeyed past that place, it was their custom (called *uruuru-whenua*) to break a small branch from the forest and throw it on the stone as an offering to secure them from hail and rain on their journey. The writer has been told of a similar place on the Kau-ara-paoa (Whanga-nui River); but at this place the Native gods still hold power, for on the two occasions when curiosity has led to the spot, a thunderstorm has quickly driven the curious to a place of refuge and shelter.

From that place he went on to Whaka-tara (about eight miles from Turakina up the river), at Turakina, where there is a *taniwha*, and then on to Putiki, from which place he travelled up the Whanga-nui River. A few miles above the Tanga-rakau tributary there is a fine reach, which he called after himself. Then on he journeyed to Taupo, gathering on his way from the river pas a crew of expert canoemen, with whom he wished to descend the Wai-kato. At Taupo a discussion arose as to which was the most difficult river to navigate. the Whanga-nui or the Wai-kato. The Whanga-nui men naturally supported the claims of their own river, so in the end the Taupo people dared the others to descend the rapids of the Waikato soon after it leaves Lake Taupo. A canoe was provided, and the Whanga-nui crew, with Rua-wharu (who was steersman on the Takitumu) at the steering - paddle, started down the river. A Taupo man accompanied them as far as a little islet just above the Huka rapid and falls, where he jumped ashore, telling the others to proceed. They did so, and were soon flying down the channel just above the falls, not knowing what was before them. They soon discovered, to their cost; and it is said that Tamatea's canoe can still be seen under the falls, held tight by the force of the falls in front of it. (We have looked hard for that canoe, but so far have failed to discover it.)

So perished Tamatea and his crew. As canoemen, their skill and bravery counted for nought amidst the thundering waters of the Huka. It was doubtless a pleasing incident to the men of Taupo, and proof positive that Whanga-nui had much to learn from Wai-kato.

[Note.—The above story originates at Taupo. Old chiefs of the Ngati Kahu-ngunu Tribe allow that Tamatea lost his canoe at the falls, but they affirm that he himself was saved. In proof of this the writer was told the story of Tamatea's after-life, and the narrator also affirmed that he and other direct descendants from this old ancestor knew the cave where he was buried, and had seen the place.]

One of Tamatea's sons migrated to inland Patea about eighteen generations ago. His name was Tama-kopiri. He was the founder of the Ngati Tama Tribe. He came from Tu-ranga, but the present-day Natives at that place do not recognise him as one of Tamatea's sons. If not a son of the captain of the Takitumu, he was certainly descended from one of the Tamateas of that period—probably Tamatea Kopiri.

I have obtained a few notes relating to his wars, also an account of his death, which is worth placing on record, and is as follows :—

Tama-kopiri came to Patea with a *taua*, and made war on the Ngati Hotu there (the Ngati Hotu were an aboriginal tribe formerly owning Taupo). He was victorious, and so went on to Kaki-kino, where he again found the Ngati Hotu gathered, and a second time he attacked and conquered. He also found them at O-tama-kura, on the edge of the Opakaru bush, also at Nga-pukara-nui and Pae-tutu, and in all these various engagements Tama-kopiri and his party were victorious. After all this fighting, the Ngati Tama, under the chief Tama-kopiri, attacked Te Kumete, which was the name of a settlement near Kauanga-roa belonging to Hai-rangi, who was the father of Kahu-kaka. At this place the daughter of Matapou, and granddaughter of Hai-rangi, was killed by Tama-kopiri. Her name was Tu-kai-rongo-reupea.

One evening Hai-rangi and his granddaughter went down from Aro-mango on a visit, and slept at Te Kumete. On their return the next day, they got as far as Houhou, on the banks of the Rangi-tikei River, near Rata, when they found the pa was surrounded by the war-party. They endeavoured to return unseen, but it was too late; they were perceived by the enemy, and Tama-kopiri started off in pursuit. Some of his people wished to go with him to assist; but he would not allow them, and said, "You stay here: I am a chief, and can look after myself." On hearing this remark. Hai-rangi knew that he was being pursued by a rangatira, and so made all haste to get away; but, being on old man, and encumbered with the girl, he was unable to gain on his pursuer. He therefore hid his granddaughter in a flax-bush, and covered her with his own garment, thinking that, as his pursuer was a chief. if he happened to find her he would spare her life. After he had hidden her away he crossed over a stream and went up on a hill where there was a hawk-snare set, from which place he could look down and see where his grandchild was hidden, without being discovered himself. After a time Tama-kopiri came along searching, and when he found the girl he speared her, and went on looking for her companion. Hai-rangi. looking down, saw all that happened, and with great anger he seized the hawk-snaring stick, rushed down the hill, attacked and killed Tama-kopiri with it; and this hill on which he was slain was afterwards known as Puke-o-kahu (the hill of the hawk). After killing Tama-kopiri, Hai-rangi scalped him, hung the scalp on his belt, and went cautiously back to see how it fared with the people in the pa. He climbed up an eminence overlooking the place, and when he found they were still all right, he called out to them. telling them what had happened. and sang about the death of his grandchild. When the war-party heard him they looked up, and saw Tama-kopiri's scalp hanging to the chief's girdle. This frightened them, and so, instead of further fighting, they proceeded to make peace, which was agreed upon by the people of the pa. although they still sought an opportunity of destroying that war-party; and so it happened that one day, when the people of that party were just below, the pa, digging fern-root, Hai-rangi and his people rushed down upon them, and before they had time to protect themselves many were killed; but the only person of note killed was Tama-kopiri, previously cut down and scalped by Hai-rangi. The chief Tama-tapui was in the Aro-mango Pa on this occasion.

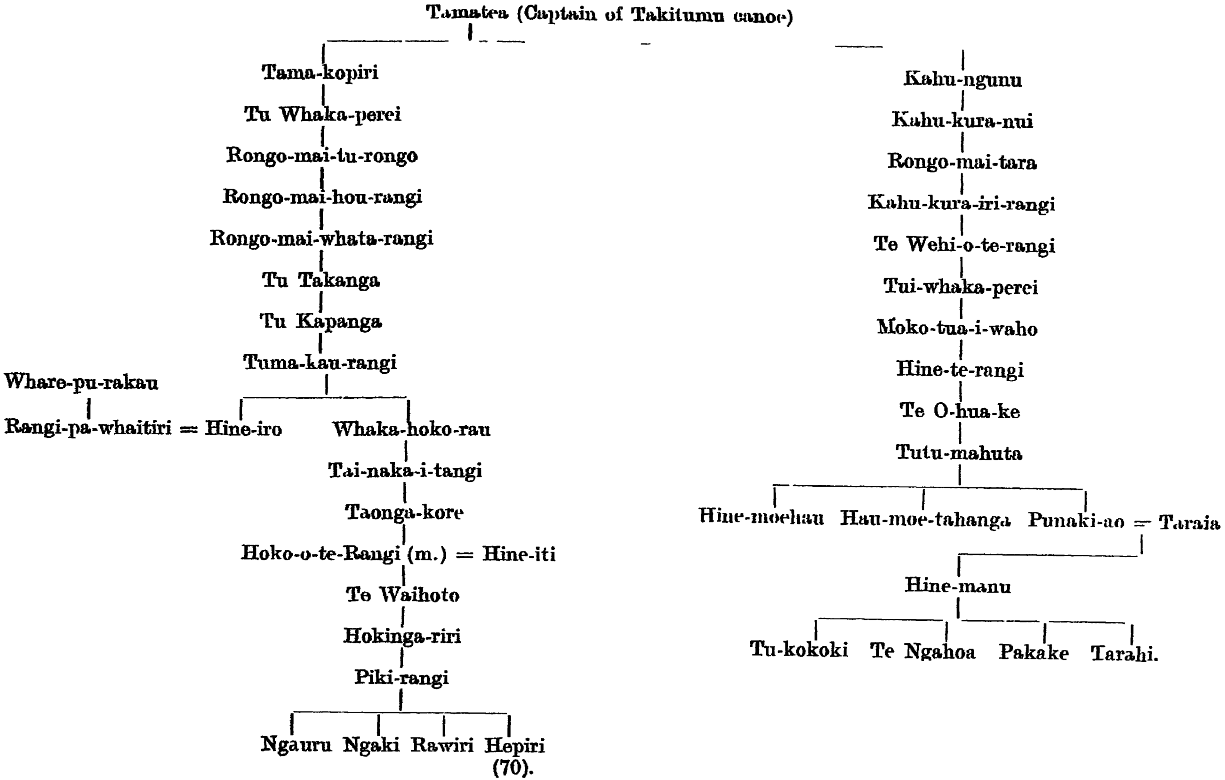
On the next page is a genealogical table showing Tama-kopiri as a descendant from Tamatea, also some of the descendants of Kahu-ngunu; but, as previously stated, it is a disputed question whether these two were brothers. Indeed, many of these tables are rather conflicting, and, although the utmost endeavours have been used to glean the truth, chiefly by comparing one man's statement with another's, yet it is difficult to eliminate all error. For the most part, I have written the narratives as I have received them, only making such alterations as were necessary.

For further lines of descent from Kahu-ngunu see Jour. Polynesian Soc., vol. v, p. 7.

Another *whakapapa* in my possession shows Tama-kopiri twenty generations back.

Another visitor who arrived and journeyed through the district, eventually settling here, was Ma-tangi, who came from Wai-rarapa about eighteen generations ago. He came hither, having heard that the place swarmed with flocks of birds (*whirikoko* = a flock of birds in flight). When he reached the summits of the Tara-rua Mountains he saw the first flight, so he called the place Tiro-hanga. The flock alighted at Tahuna-a-rua (near Palmerston North), so he followed them: but when he drew near they arose and flew very high—hence the name of Te Ao-rangi (near Feilding). They next alighted at Purakau, below Whaka-ari (trig. station between

TABLE 2.


Tamatea (Captain of Takitumu canoe)
Tama-kopiri
Tu Whaka-perei
Rongo-mai-tu-rongo
Rongo-mai-hou-rangi
Rongo-mai-whata-rangi
Tu Takanga
Tu Kapanga
Tuma-kau-rangi
Whare-pu-rakau
Rangi-pa-whaitiri = Hine-iro
Whaka-hoko-rau
Tai-naka-i-tangi
Taonga-kore
Hoko-o-te-Rangi (m.) = Hine-iti
Te Waihoto
Hokinga-riri
Piki-rangi
Ngauru
Ngaki
Rawiri
Hepiri (70).
Kahu-ngunu
Kahu-kura-nui
Rongo-mai-tara
Kahu-kura-iri-rangi
Te Wehi-o-te-rangi
Tui-whaka-perei
Moko-tua-i-waho
Hine-te-rangi
Te O-hua-ke
Tutu-mahuta
Hine-moehau
Hau-moe-tahanga
Punaki-ao = Taraia
Hine-manu
Tu-kokoki
Te Ngahoa
Pakake
Tarahi.

Sandon and Awa-huri usually called Mount Stewart), in the bush; but again he disturbed them, and they flew on to Taumata-patiti. Next they alighted in the bush called Te Rakau-hou, near Mount Stewart. Matangi went into the bush, but found that the birds did not stay; and, as the trees were young, he gave the name above mentioned. Again they alighted in the bush, where he slept with his face to the ground; therefore he called that place Te Whaka-moe-takapu (near Kaka-riki), (railway-bridge near Greatford). Still following the birds, he arrived at a new country, and, taking a pole, he took a leap with it, calling the place Tokorangi (a hill between Halcombe and the river on the cliffs above the Onepuhi Pa). Still following them, he reached a stream where he recited *karakias;* therefore he called the stream Wai-tapu (near Rata, one of the boundaries of the Manawa-tu Block). Again he followed the birds, and caught the sound of them, and so called the place Paroro-rangi. There are two ranges meeting at an angle—one is Paroro-rangi; on the other he stood and blew his horn. calling it Puto-rino (between Hunterville and the Rangi-tikei River). Still following the birds, he reached the upper Rangitikei, and, seeing that they had taken flight inland, he called the spot Tirohanga; but the place is now called Te Papa-o-Hauiti (Rata). He followed them to the top of the ridge, where he halted and stamped on the ground, and so called the place Tapuae (a trig. shown on most maps). Again he went on, and, seeing them high up in the air above him, he called the place O-tama-kapua. Then he went along the river and again blew a blast on his horn, and there he called the place Puta-tara. Still on up the river he went till he came to a place where he grounded his staff, and called it Te Tokotoko-o-Matangi. Then he climbed the range and reached the top, calling it Whaka-ara-waru. From this place he watched the birds cross the river, and saw them alight; therefore he called the place Rangi-tauria. He was now almost exhausted, and gave up the chase; but the birds were also tired, and could not fly any further: so he and his children (for his children had followed him all the way) caught and killed them, and there they stayed and settled, and his children are still living at Rangi-tauria to this day.

"If you ask me," continued the old man who gave the narrative, "whether I have been there and seen them, I answer Yes. I have seen the place, and have seen his children. They have been changed into 'spirits of the brook'—*i.e.*, *taniwhas*—because they disobeyed the voice of their father when he told them to bring some water. I have myself seen the posts of his house, for they are still standing (450 years since that house was built). I have seen his children with my own eyes. If we all went up to them it would make no difference. Many attempts have been made to secure them with ropes, but in vain—they can release themselves at once by their magic powers. Their names are Hine-te-iwaiwa and Horoputa, her brother, and they are still at that place, for there Ma-tangi left them." The lake which Ma-tangi's children still inhabit is near O-kaharau, and is called O-toea. His house was built at Whiti-anga, near the lake, and it was there that our friend saw the totara posts. It was Matangi who brought to this land the *atua* Kahu-kura, which came from Hawaiki in the Takitumu canoe. This *atua* was first taken to Te Awarua, but in the time of Te Ngahoa it was removed to Owhioi. All inquiries regarding the shape and power of this *atua* have yielded but little information beyond the fact that it was very large, and shone like fire, something after the shape of a comet, and had power of flight or movement. (Other accounts affirm that Kahu-kura was lost at the Huka Falls when Tamatea's canoe went over.) After Ma-tangi's children left him he was returning to his old home, accompanied by his dog. He travelled down the Rangitikei River, but had the misfortune to lose his dog; and, as its name was Ranga-tira, he went about calling "Ranga-tira, Ranga-tira"; so that place was ever afterwards known as Ranga-tira (a well-known block between the Pou-rewa and Rangi-tikei Rivers). Many of Ma-tangi's descendants intermarried with Ngati Hau-iti.

TABLE 3.

Ma-tangi
|
Tapairu
|
Hitamia-aro
|
Te Au-te-peao
|
Forgotten
|
Rangi-tua-uira
|
Tumokai

|
Matangi 2nd
|
Rua-anga
|
Whaka-urua
|
Putai
|
Te Kiri-kai-ngaere
|
Taongi
|
Potaka
|
Utiku-Potaka
|
children
|
grandchildren.

|
Tuhi
|
Hapainga-te-Rangi
|
Tangaio
|
Hine-huanoa (f.) = Te Wai-hoho (m.)

[NOTE.—One of Utiku Potaka's grandchildren is named after one of the *taniwhas*—namely, Hine-te-iwaiwa.]

CHAPTER II.

The history of the next period is almost a blank. The early history of the Ngati Apa proper, as far as their traditions give us any enlightenment, extends back some twelve generations, when the founders of the tribe came into the district under the following circumstances:—

Apa-hapai-taketake, a son of Ruatea, who came in the Kura-haupo canoe, was an ancestor of the Ngati Apa, and to him this somewhat ill-fated tribe can trace the beginning of their misfortunes, as they trace their names. He seems to have coveted a pet moa (*he mokai*) belonging to Ngati Tu-whare-toa, and, not being able to restrain his desires, he stole the bird and made off with it; but, unfortunately for him, in this adventure he fell over a cliff and received an injury that resulted in permanent lameness;

hence his companions, with fine humour, ever after denominated him Apa-koki (Hop-and-go-one). Being a man of energy, he managed to get off with the bird in spite of his accident; and, if tradition speaks truly, he and his friends obtained a fine meal. When Ngati Tu-whare-toa discovered the theft, they naturally felt aggrieved, and soon started out seeking *utu* for the stolen moa. They returned home well satisfied, bringing with them Hine-moatu, the wife of Apa-koki. This roused the ire of Apa-koki, and in great wrath he seized the kumaras of Kawerau; whereupon Ngati Tu-whare-toa, in equal wrath, came down on Ngati Apa under the chief Awa-tope, and drove them from their home at Puta-uaki, near the Awa-o-te-atua (Mount Edgecumbe. in the Bay of Plenty); and so they fled, and came to Manga-nui, on the upper Rangi-ta-iki; but Awa-tope still pursued, and forced them south till they came to Roto-a-ira, where they settled.

The following table shows Awa-tope as a descendant from Kahu-ngunu:—

TABLE 4.

Tamatea
|
Kahu-nganu
|
Whaene
|
Taka
|
Hou-rangi
|
Uira-roa
|
Rongo-tangi-awa
|
Ira-peke
|
Awa-tope.

Toroa (Captain of the Mata-atua canoe)
|
Rua-ihonga
|
Tahuna-a-te-ia
|
Awa-nui-a-rangi
|
Rongo-tangi-awa

These are the Ngati Awa of Whaka-tane.

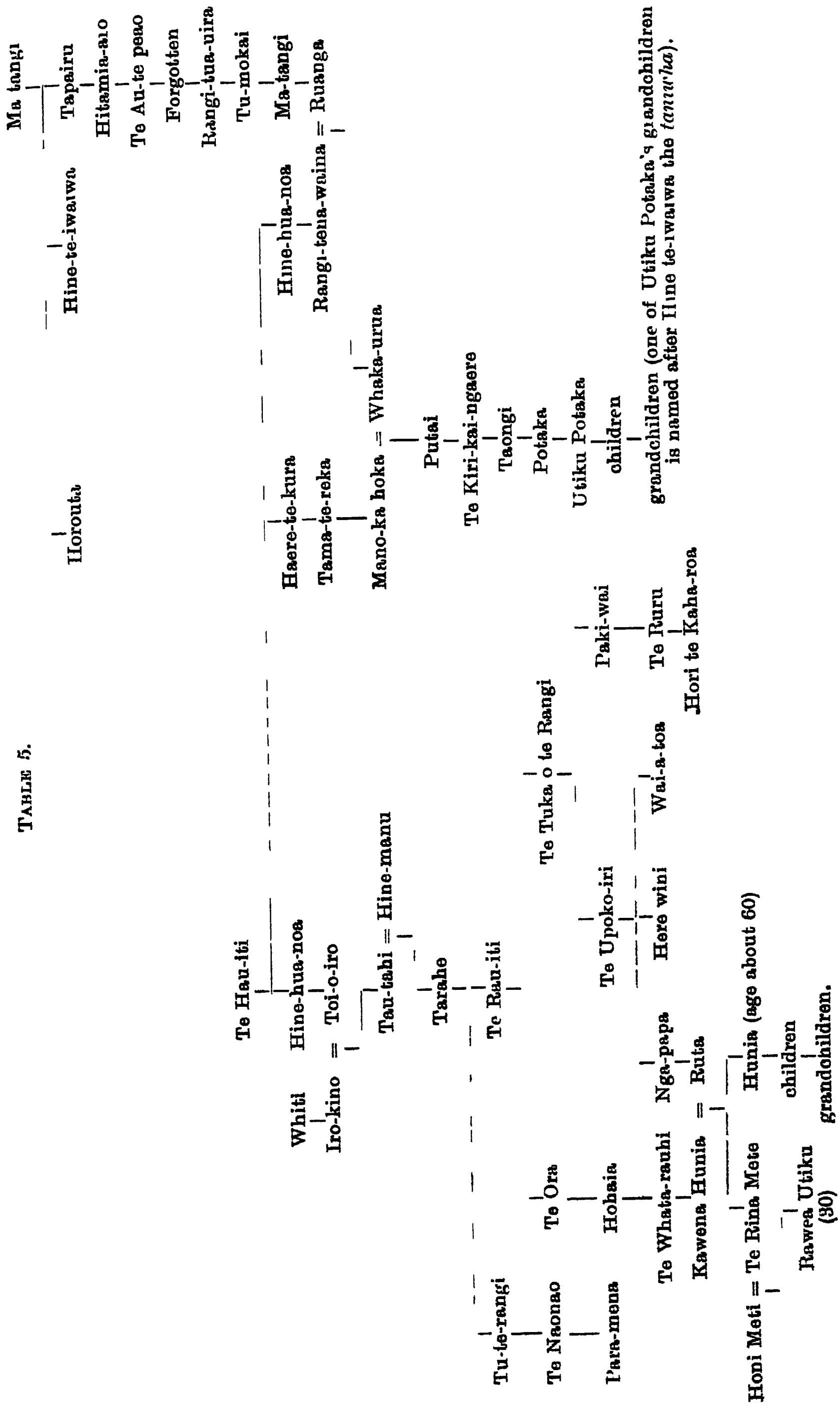
Seventeen generations more to the people living in the Bay of Plenty at the present time.

They had not been established at Roto-a-ira very long before trouble arose owing to a dog being killed. The animal's name was Te Rangi-a-kopu-takere, and it belonged to a man named Ripo-a-rangi, of Ngati Tu-whare-toa. The man who brought this trouble on the Ngati Apa people not only killed the dog, but he roasted and ate it when in the bush by himself. As he was suspected, a woman smelt his breath while he was asleep, and, detecting the dog-smell, quickly reported her discovery to the owner. In revenge for the death of his favourite, Ripo-a-rangi gathered his family and came down upon the Ngati Apa, taking the pas Tauwhare-papa-a-uma and Motu-roa. After these pas were taken, peace was made, which lasted till a man named Ma-tangi killed his wife Hine-mihi in a fit of jealousy because of Miromiro, who had been paying attention to her. As her relatives belonged to Ngati Tu-whare-toa, the latter besieged a pa belonging to Ngati Apa called Rangi-te-taia. Tu-te-tawhoa, the leader of the Ngati Tu-whare-toa, and his party approached the pa on one side, while he sent another party to the opposite side; but when Wai-keri and Rakei-poho, of the besieging forces, entered the pa they found it empty, the Ngati Apa having evacuated during the night. The pursuit was followed up, and the chief Ma-tangi killed, as well as a great number of his people, while many were taken prisoners. Those of the latter who were spared were taken to Inland Patea, where they were kindly treated. One of the prisoners taken on that occasion was Te Rehu, Ma-tangi's son. Afterwards when he grew up he escaped and went to seek help from the Ngati Tama to avenge his father's death. They responded, and the war-party so raised went to Tauranga Taupo (about twelve miles from Toka-anu, on the Toka-anu – Taupo Road), and there attacked the Ngati Tu-whare-toa at the Horo-tanuku Pa. They seem to have been repulsed, one of their chief men, Te Iwi-kinakia, being killed and eaten. The attackers now became the attacked, for as they returned home they were followed up by Ngati Tu-whare-toa, who killed Tuma-kau-rangi, of the Ngati Tama Tribe, and Haere-te-kura (Hau-iti's son), of Ngati Hau-iti, at Rangi-po. Such a defeat required to be wiped out with blood, so another party was organized to avenge those deaths. Tama-kai-tangi and his brother Hika-kainga, also Hau-iti, accompanied that war-party, and they obtained what they sought, for they captured the pa Hawera-roa, and then went on to Kapo-a-rangi, where they killed Rakei-atu, but they spared Ripo-rangi, who was captured by Hika-kainga. The war-party then went on to Taupo, where they were attacked by the Ngati Tu-whare-toa; but peace was made when it was known that Ripo-rangi had been spared in the previous fight; so that war-party then returned to their homes.

In the meantime the Ngati Apa people had rapidly been extending themselves throughout this new country. From the time they arrived at Roto-a-ira they had been sending companies south, so that when the main body migrated they had settled pas and extensive cultivation in many of the inland districts, as well as right down the Rangi-tikei River to its mouth.

It was soon after Ngati Apa were settled in this new country that Hau-iti (the ancestor of the Ngati Hau-iti Tribe) left his fighting-pa, Ara-o-tawhaki, and started for Taupo to avenge the death of his son Haere-te-kura, who had been killed in battle by the Ngati Tu-whare-toa people, as related. He left his pas O-tau-eru and Rongo-motumotu at Ranga-tira in charge of his younger brother Ka-ama; but Ngati Apa took advantage of Hau-iti's absence, killed and ate Ka-ama, seized Rongo-motumotu (on the Rangi-tikei River, near Rata), as well as several other pas in the vicinity. A messenger was hurriedly sent to Hau-iti, who returned with all possible haste and pursued Ngati Apa, who took refuge in Tà-pora-pora, a pa belonging to Hau-iti. Driven out of this place, they fled to Te Ara-o-tawhaki, evacuated by Hau-iti when he left for Taupo. After the fall of this pa they retreated to Puapua-tanaki, one of the pas which they had taken from Hau-iti, and here they found a secure retreat. After this Hau-iti was killed by Pukeko, a Ngati Apa man, at a place which still bears his name, Te Papa-o-Hau-iti (Rata); and his descendants sought to avenge his death by attacking a pa called Oti-haupu, on the south-east of the Rangi-tikei River. They were successful in this venture, for a great number of the Ngati Apa people were killed, but a few, among whom were Hatea and Rangi-whiowhio, were spared. When the Ngati Hau-iti had taken this pa, they assaulted the Wharewhare-riki and Po-takataka pas (on the O-tama-kapua Block), both of which were taken. The Ngati Hau-iti were then satisfied, and returned home. The large force that attacked these pas was gathered from Inland Patea, O-tara, O-tau-eru, and the upper Rangi-tikei, and the fighting took place in the time of Whare-purakau, contemporary with Tama-te-raka and Iro-kino, and was in revenge for the death of Hau-iti.

TABLE 5.


Ma-tangi
Hine-te-iwaiwa
Tapairu
Hitamia-aio
Te Au-te peao
Forgotten
Rangi-tua-uira
Tu-mokai
Ma-tangi
Hine-hua-noa
Rangi-teua-waina = Ruanga
Horouta
Haere-te-kura
Tama-te-reka
Mano-ka-hoka = Whaka-urua
Putai
Te Kiri-kai-ngaere
Taongi
Potaka
Utiku Potaka
children
grandchildren (one of Utiku Potaka's grandchildren is named after Hine-te-iwaiwa the *taniwha*).
Te Tuka o te Rangi
Paki-wai
Te Ruru
Hori te Kaha-roa
Wai-a-toa
Te Upoko-iri
Here wini
Te Hau-iti
Whiti
Hine-hua-noa
Iro-kino = Toi-o-iro
Tau-tahi = Hine-manu
Tarahe
Te Rau-iti
Tu-te-rangi
Te Naonao
Te Ora
Para-mena
Hohaia
Te Whata-rauhi
Nga-papa
Kawena Hunia = Ruta
Honi Meti = Te Rina Mete
Hunia (age about 60)
children
grandchildren.
Rawea Utiku (30)

CHAPTER III.

Another dispute took place in the upper Rangi-tikei district about the time of Whare-pu-rakau (see Table 2), when the Ngati Wahine Tribe came from Here-taunga (Hastings). They came, a great army, with boasting and pride, but they left with defeat and disaster, for they were opposed by Tamapo and the sons of Tu-ka-roua at Whiri-nga-otau, and there they left their pride as food for their adversaries. Those who escaped the battle hid in a cave called Ana-roa at Atu-pae, where they also were cut off by hunger and exposure. As soon as their friends became aware of the fate of the *taua*, they determined on revenge, and raised a second party to send over to conquer the victors; but again their intentions were brought to nought.

It seems that a lady named Punaki-ao (see Table 2), from the upper Rangi-tikei, was taken as a wife by Taraia (her own husband being away at Whanga-nui at the time), and the two fled away to Here-taunga, and dwelt there at Puke-hamoamoa. After a time Tutu-mohuta, who was Punaki-ao's father, left his home at Awa-rua and went to visit Taraia and his daughter. As soon as he arrived, Taraia asked him if he had met a war-party on his journey, and, as he replied in the negative, Taraia advised him to return immediately, telling him of the intention of the Ngati Tama-wahine to take Patea. Without loss of time Tutu-mohuta returned to Te Awa-rua, but found he was just too late, for the fires were still burning where the war-party had cooked the father of Whiti-kaupeka, who belonged to Ngati Hau-iti; but the enemy themselves had gone. The chiefs of the Here-taunga party were Rua-te-kuri, Tawhao, and Rangi-tau-ira; and the manner of their attack was as follows: Coming upon Whiti-kaupeka's party suddenly, they feigned hunger, and asked Whiti for his dog as food, and when this was denied them they killed the dog. After it was cooked they offered some to Whiti, who, wishing to prevent trouble, took it; but while he was eating they suddenly set upon him and killed him. As soon as Tutu-mohuta found out which direction the war-party had taken, he and his wife followed them up, and came upon them at Manga-weka. The war-party tried to detain them until the morning, intending to kill them during the night; but they escaped unobserved, and reached O-hinga-iti, where Tumehau and Tumoro, with a large party, had gathered to resist the invaders. Immediately on their arrival a meeting was held to decide on the best course of action, and while they were gathered the war-party came upon them unexpectedly, being in the pursuit of Tutu-mohuta. They fought there at O-hinga-iti, the inland tribes combining to resist the invaders; with the result that Ngati Wahine were defeated, and their leaders Rua-te-kuri and Tawhao slain; but Rangi-tau-ira and Tu-purupuru escaped. But again misfortune dogged their steps, for, having reached Manga-o-hunu on their way back to Here-taunga, they were overtaken by a severe snowstorm, so they took shelter in the cave O-huake (on the Rangi-po Plains); but, as the cold continued, they, and their followers also, perished through hunger, cold, and exposure. In this fight the invaders killed Tamapo, who had previously resisted them; but otherwise they had but little success, while their own party was practically exterminated.

After this fight Ngati Tama, Ngati Whiti, and Ngati Hau-iti lived together as neighbours on the west side of Moa-whango.

Soon after this affair Tahuna, a Ngati Apa chief, and his party travelled from Whanga-nui to Rangi-tikei to visit Whare-pu-rakau. All went well till one day Whare-pu-rakau returned from a hunting expedition in the bush and found his son Rangi-pa-whatiri covered with blood, and upon inquiry he learnt that Tahuna's child had beaten his son. He therefore killed Tahuna's child, and the father, in fear for his own life, fled back to Whanga-nui, where he collected a war-party about eight hundred strong and travelled back to Tawhiti, on the Rangi-tikei River, where Whare-pu-rakau had gathered Ngati Tama, Ngati Whiti, and Ngati Ohuao to resist the inevitable attack. For a time Tahuna and his party camped on the river-bed, subsisting on Whare-pu-rakau's kumaras, which they stole at night; but, as soon as Whare-pu-rakau's people discovered the position Tahuna had taken up, they resorted to stratagem, and threw a great quantity of wood and rubbish in the river to make Tahuna think a flood was coming, and that they (Whare-pu-rakau's party) would not be able to cross over to the attack. Tahuna's party saw the rubbish, and hurriedly left the river-bed and went inland; but while so engaged Whare-pu-rakau attacked them. In the fight that followed (known as Waha-kaka-roa) it is related that Whare-pu-rakau had a certain *taiaha*, but he was struck and disabled by the enemy, consequently was unable to use it. He afterwards made a proverb to the effect that if his weapon had only been long enough he would not have been wounded; hence his uncle took the name of Tu-whaka-uru. When wounded, Whare-pu-rakau discarded his *taiaha* and took a long spear, and, although wounded, succeeded in killing Tahuna, whose party, seeing their leader fall, gave way and fled. They were pursued night and day, and it is said their bones may still be seen along that path (excepting perhaps Tahuna's ribs, which were made into a bird-snare, which snare is still in a matai-tree somewhere at Moa-whango).

This may be so, but we pakehas doubt if a snare would last for two hundred years exposed to all weathers; yet it is asserted that some of Whare-pu-rakau's spears are still to be seen on Mr. Batley's farm at Moa-whango. They are imbedded in a large and hollow cabbage-tree, where they were hidden, the tree eventually growing round them and gripping them as part of the tree itself. It is also related that Whare-pu-rakau was a very athletic man, and, near his place on the upper Rangi-tikei, he on several occasions saved himself from pursuit by clearing at a jump a narrow part of the river where the cliffs nearly meet. No other man would venture this hazardous feat; so he could defy his enemies, and often did so. He lost his life by drowning in the Rangi-tikei River. As his party were crossing a dangerous ford, his wife got into difficulties, and in going back to assist he himself lost his life, though his wife was saved.

Again Whanga-nui started on the war-path against Ngati Tama, whom they found living on the land between Moa-whango and Hau-tapu. A battle was fought in which Whanga-nui was defeated, Nuko and Tuahungia being slain. The invaders fled, and were pursued by Ngati Tama as far as Wai-paruparu. After this invasion the inhabitants of the Potaka Pa (just above the Awa-ua Pa) heard that they were about to be attacked by the Ngati Apa and other tribes. At this time there were no Ngati Tama in the pa—they were all away at Taupo; while most of the Ngati Whiti and Ngati Upoko-iri were away at Here-taunga. Before they could obtain assistance the *taua* came down on them. Te Kahu-o-te-rangi, of the Ngati Apa, and Nga-makako, of the Tu-heke-rangi, were the principal chiefs, and their followers numbered eight hundred men, gathered from Whanga-nui, Whanga-ehu, and Turakina. When the *taua* reached Potaka, they found that the people of this pa (mostly Ngati Hine-manu), although warned of their coming, were quite unprepared, for a number of men, among whom was the chief Whanau, were surprised and killed while gathering matai-berries. Then the pa was surrounded and the siege commenced, but after four days Te Kata managed to slip out of the pa unseen, and escaped through the enemies' ranks to seek assistance. He fled to Here-taunga to bring over the people of the Ngati Hine-manu Tribe, who were living there. He was successful, and the chiefs Tao-rangi, Maka, Toia-iho, and Tu-te-rangi, with their men, hastened back with Te Kata to help their kinsmen. Under cover of darkness they obtained entrance to the pa by ropes being thrown to them; and next morning, being so strengthened, a sortie was made on the besiegers, who quickly discovered, during the fight that ensued, how the garrison had been strengthened. So many of the enemy were killed by this sudden onslaught that they thought discretion the better part of valour, and so decided to sue for peace.

Te Kahu-o-te-rangi called out his desire to Tao-rangi, who agreed to the request, so Te Kahu-o-te-rangi was taken into the pa, where presents of food were made and hakas sung, and so the peace was confirmed.

In this fight, which was called Tini-o-te-kotiri (on account of the large number taking part in it), the Ngati Apa party killed Tama-kahuri-rangi, of the pa, and his death was afterwards avenged by a party from Te Awa-rua Pa, who travelled as far as Manga-whero taking prisoners, who were killed and eaten. They also journeyed to Turakina, where the Ngati Tu-heke-rangi and the Ngati Wai-riki were severely defeated. But though defeated in this fight they were by no means conquered: the spirit of battle only burned with a fiercer flame, and the shame and ignominy which tarnished their proud name had to be wiped out at all cost. On reaching Whanga-nui they at once reconstructed, more determined than ever to wipe out their defeats, and this time cautiously divided their forces, one half going to attack Ngati Hine-manu and Ngati Hau-iti on the east side of the Rangi-tikei River, and the other half going to attack Ngati Tama and Ngati Whiti on the western side. This time the fortune of war was with them—Ngati Tama were defeated, and their chief Te Hainga and many others slain. And so the gentle game of "tit for tat" went on. Ngati Tama now sought *utu* for those deaths, and started from Motu-kawa with vengeance quivering in every nerve of their bodies. Again they were successful at Turakina, where the chief Taputu and several of his men met their death and "chief's burial." After this victory Ngati Tama returned to the western side of the Rangi-tikei, and when they arrived they found new troubles had commenced, and fresh work was in store for them; for their kinsman Rangi-pa-whitiri (Whare-pu-rakau's son) had just been despatched to the happy hunting-grounds. This chief had two wives, one belonging to the Ngati Kahu-ngunu, and the other, whose name was Hine-iro, was related to the Ngati Tama and the Ngati Whiti tribes. Rangi-pa-whitiri collected food for a feast, and took the food so gathered to the first-mentioned wife as a present to her. Hine-iro was very angry about this, for she considered the food had been gathered on her land, consequently it should not have been given to a stranger; so she gathered together a war-party of the Rua-kopiri and killed her husband Rangi-pa-whitiri. When the enraged lady's *taua* had completed this mission they returned to Whanga-nui.

Then Ngati Tama and Ngati Whiti started off to avenge his death under the chiefs Hoko-o-te-rangi and his uncle Te Kiore; and at Pakaka (Karioi) they killed Tu-rere, and captured his son Tukai-ora. When Tukai-ora was taken prisoner he was loaded with calabashes, which were to hold the flesh of the slain after it had been rendered down. But he, watching for an opportunity, threw them off, killed four of his captors, and escaped. From this great warrior descended Pehi Turoa of Whanga-nui, thus :—

TABLE 6.

Tukai-ora
|
Hitana
|
Pehi Turoa
|
Te Rangi-hopuata
|
Topia Turoa
|
Kingi
|
Kingi 2, of Whanga-nui.

As Hoko-o-te-rangi and his party were returning after their victory they were followed by a Nga Rangi *taua* from Whanga-nui, who came upon them at Wai-tangi. During the fight that took place Te Kiore saw that his party was likely to be worsted, so he called out to Hoko-o-te-rangi. " Escape while you can ; go and live as a chief at Mokai Patea ; I will carry on the struggle without you." Hoko-o-te-rangi replied, " I will not hide myself, for I am a chief. As I have sought this quarrel, I will carry it through and fight the enemy." So they continued the fight, and soon both Te Kiore and Hoko-o-te-rangi were killed, and their party utterly routed. The survivors fled to Mokai Patea. It may be mentioned that Hine-iro and Te Kiore were brother and sister.

After Tukai-ora escaped and reached Whanga-nui, word came through that Ngati Whiti and Ngati Tama had killed Tuhongia and Miki on the west side of the Moa-whango. Whanga-nui went out, fought, and gained a battle, in retaliation ; but, not satisfied, took out another war-party, and captured a pa called Kiri-weka, where Rangi-wha-rawarawa, Horua, and Kai-toha were taken prisoners.

After this, Ngati Apa murdered Te-ihu-tu at the O-tau-eru Pa (Taupo), which was occupied by Ngati Hau-iti ; and so Ngati Hau-iti came down in full force on the Ngati Apa, whom they met in open field, and, after a severe struggle, defeated. Then they attacked the pa at Kaka-riki, which they took, killing a great number, and making several prisoners, among whom was Puao. In revenge for this Ngati Apa killed the chief Tu-tohu at Pou-rewa, at a place called Pukiore (Pukiore is west of Makohine Viaduct, near the Pou-rewa), and his death was avenged at the Pa-kihi-roa battle, fought at Tara-ketu (Manawa-tu). This battle was fought at the pa called by this name, and Ngati Apa were defeated. Again they were defeated in a fight where both sides met in open country at upper Tutae-nui. Ngati Hau-iti, not yet satisfied, assaulted the pa of Taumata-maire, in the district of Whaka-tara, which they took, and then returned home. Ngati Apa now sought reprisals at Mokai Patea, where they met Ngati Hau-iti and killed Repa-rangi and Te Pu-o-te-rangi, the former chief belonging to Ngati Whiti and also Ngati Tu-whare-toa. On hearing of this, Ngati Hau-iti started in pursuit of the Ngati Apa forces, and overtook them the next day, and in the action that ensued the entire Ngati Apa party was cut off, as they were few in number, while Ngati Hau-iti were strong, having obtained help from the Ngati Whiti, the Ngati Tu-whare-toa, and the Ngati Tu-mokai tribes. Flushed with victory, they still pushed on in hope of further success, when they were met and defeated by another *taua* of Ngati Apa at the battle of Te Taku-o-te-rangi, at a place called Korero-mai-waho (now Greatford). This defeat was avenged at the battle of One-puhi, where the combined forces of Ngati Hau-iti and Ngati Whiti overthrew Ngati Apa, who were not strong enough to resist them at that place, but who followed Ngati Hau-iti on their return journey, and overtook them at Pari-roa, on the O-roua; but the Ngati Apa force, under the chief Takiao, was defeated, and their leader slain. Some time after this fight at Pari-roa there was another great engagement, at Kai-inanga (a pa near the junction of the Hau-tapu and Rangi-tikei rivers), in which Ngati Apa were victorious, although fighting against the combined tribes; but before this, and during the interval between the two battles, there came from the north the Tu-whare - Te Rau-paraha expedition under the leadership of Waka Nene, Patu-one, Te Rau-paraha, Tu-whare, and others. They had a few guns in the party, and, as this was the first time these weapons were seen on this coast, the havoc they wrought was tremendous. This *taua* came down somewhere about 1819 or 1820, and it was this journey that gave Te Rau-paraha the idea of migrating to Kapiti, to be near the centre of European trade, which idea he put into practice about 1822, when his whole tribe (the Ngati Toa) removed thither. In order to strengthen his position, he induced the Ngati Rau-kawa to make *hekes* (some of which we are able to describe) to his newly acquired land. From this time up to about 1825 the great Ngati Toa chief was actively combining business with pleasure in endeavouring to exterminate the whole of the Mua-upoko Tribe. Then the Ngati Rau-kawa chief Te Whata-nui, who had previously accompanied two or three of the *hekes*, intervened, and stayed his hand by taking up his residence at Horo-whenua, where eventually he died. Here he was looked up to as an ally and protector by the Mua-upoko, which indeed he was, for it was certainly he who saved these people from annihilation. Full accounts of these affairs have been published in "The Life and Times of Rau-paraha," and also in the Jour. Polynesian Soc. in a fine paper by Mr. S. Percy Smith, entitled "Wars of the Northern against the Southern Tribes";* therefore little more need be said.

Before adding a few brief notes of these wars, some further details of fighting that occurred prior to these events can be given. "After the capture of Kiri-weka," said Major Kemp, in evidence given before the Land Court at Whanga-nui, "my grandparent went with a war-party to a place called Opetaka, on the Rangi-tikei River, and there killed Taka-rere and Rau-awa, and made prisoners of Ro-onga, Te Maka-taha-hapa, Pu-ronga, and others of the Ngati Whiti, Ngati Tama, and Ngati Hau-iti tribes. Afterwards took place the expedition of Te Mawai, the ancestor of Mohi Matene. He and his people went to Awa-rua, and, as visitors, stayed a short time with the people there, until one day Tara-mai-nuku said to Te Mawai 'Get out your weapons.' By these words Te Mawai interpreted trouble, so he got up with his spear in one hand and a *pouwhenua* in the other, warned his company, and then advanced to the assault-at-arms. In the fray that followed, Te Mawai killed Tara-mai-nuku, and then killed all the people of the pa; and no payment was ever exacted from the Whanga-nui tribes for their victory.

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* I am greatly indebted to Mr. Smith for the use of his notes, also for his many corrections and suggestions.

"At Otairi, close to Ohingaiti, on the river-flats, some of Hakaraia's people were killed—namely, Rangi-kau, Kahu-aki, and others. Payment was obtained at Whaka-rau-wai, on the other side of the Rangi-tikei River, where the chiefs Ko-pare, Te Marama, and others were killed. The war-party then crossed the river to the west side of Rangi-tikei, and there Moe-roa called out, 'Who can reach up to heaven?' Te Ope answered, 'I can'; and he straightway put in a post as a sign to stop all quarrels (probably meaning that nothing could be gained by incessant fighting, and a better way to reach the desired goal would be to make peace). As a result of this fighting Ngati Tama fled from the district, and some settled at Kai-inanga, outside of the Rangi-tikei borders; but before doing so some of them went to Oroua and there killed Pourau.

"When they had settled at Kai-inanga, Moe-roa, who belonged half to Ngati Apa, and was there before they came, became alarmed, and thought, 'Perhaps these people will become strong and take my land'; so he gathered his people, and fell on the Ngati Tama at Kai-inanga, and killed Rere-mai, Pokai-kaka, and Te Oti, as well as a great number of the people. Tahataha made a prisoner of Hine-iti, whom he saved alive."

So ends Kemp's version of the Kai-inanga fight; but the real cause seems to have been infringement of the sacred law of *tapu.* A chief named Poto died (Poto's wife Koipoa was Hori Kingi's sister), and, in order to have his head properly preserved, a man named Hia-kai cut it off and commenced operations upon it. While so engaged he was strictly *tapu,* and before this was removed by the tohungas he was accused of having fed himself with his own hands. Being unable to clear himself from the charge, both he and a man named Te Hopu were killed at Otawiri by Ngati Hau-iti. Te Hopu was not under the *tapu* at the time, but, as he warned Hia-kai, he was in some way mixed up in the quarrel, and had to pay the penalty with his life. As both men were connected with Ngati Apa, this tribe sent Te Ahuru to the pa where the Ngati Hau-iti and Ngati Tama were camped, on the pretext that he was the bearer of huia-feathers for the chief Pou-kaka. But his visit was a mere blind—he went to spy out the weak places of the pa; and when he returned with his report to the Ngati Apa they attacked in full force, and the battle of Kai-inanga ensued, in which the combined tribes were badly beaten with great slaughter. A fuller and better account of Te Ahuru's visit to the pa was related to me by Whatahoro, who said,—

"Te Ahuru's wife was in the pa before the attack, and, as he had previously arranged a call with her, he arrived at the place in advance of the Ngati Apa force, and when night fell he whistled across the gully for her to go to him. As he continued whistling the people of the pa said, 'Listen to the wekas—surely bad weather is approaching'; and they thought no more, but turned over and went to sleep. When they were all asleep, Hine-rua, Te Ahuru's wife, quietly went out to meet her husband, and when they met he said to her, 'Tell me which is the weakest part of the pa, and what do the people intend doing to-morrow.' She replied, 'The only unprotected part is by way of *te paepae* (*i.e.*, place of public convenience), which is quite unguarded. And to-morrow the people divide into three parts, one party of men going to dig fern-root, another going to the river to catch eels, and another, of women, going to the bush to gather hinau-berries.'

"Then Te Ahuru returned to his people, and showed them all these things; and on the morrow the Ngati Apa *taua* went round—first to the party who were down at the river engaged at their eel-spearing, whom they surprised and killed; then on to the place where the fern-root-digging was occupying the attention of the men, who also fell a prey to the *taua*; then they attacked the women who were gathering the hinau-berries: and so, when the Ngati Apa entered the pa by way of *te paepae*, there was no one there but the old and young to defend the place. Consequently Kai-inanga fell, and great was the fall thereof."

This greatly weakened them, for just before this fight Ngati Hau-iti had lost a great number of their people owing to a great *makutu*, the bewitching of the Ngati Hau-iti by the Ngati Apa. It seems the latter had fled for protection to Otara after Tu-whare's fight. The Otara (Ngati Hau-iti) were annoyed with them for staying, and consequently consuming their provisions, and spoke angrily to them about it; whereupon the Ngati Apa, in great wrath, bewitched them by their sorcerers Tu-mata-whiti and Moko, and then immediately left the district. My informant, Warena Hunia, of Parewa-nui, assures me that this man, Tu-mata-whiti, had an *atua* which had the wonderful power of shining like fire when consulted if the intended venture was likely to prove successful, otherwise it remained dull and motionless. The result was that many of the Ngati Hau-iti died of the spells laid upon them.

So far in this narrative an endeavour has been made to keep the various events in their proper chronological order, but dates have been avoided, for, although the dates have been assigned by Mr. S. Percy Smith and others to the principal raids and migrations from the north, when reference is made to these raids by Natives there is always a difficulty in knowing which one is meant; and, as events crowd together between the years 1820 and 1840, there is less chance of giving each its proper place in history; consequently it may be necessary to give a continuation of these notes as supplied by informants in narrative form, rather than cut them up endeavouring to obtain reliable order.

The fight at Kai-inanga, and also another at Pare-kaoa, took place after Whata-nui's raid. Kai-inanga was first, then came Pare-kaoa's death at Pou-kawa (near Napier), and Te Ao was killed some time after.

CHAPTER IV.

After the battle of Kai-inanga, the Ngati Apa returned to the outward part of Rangi-tikei—that is, the lower valley—but soon removed to Wairarapa for fear of an attack by the Ngati Tu-whare-toa; but from there they were quickly driven back by the Ngati Kahu-ngunu. They returned to Rangi-tikei, but on their arrival were met by the Ngati Hau-iti, who had returned to avenge their defeat at Kai-inanga. The Ngati Hau-iti people mustered at Mokai Patea, where they were met by a Ngati Raukawa *heke* (migration) of four hundred men, besides women and children, under the chiefs Te Heuheu-nui, Te Rangi-mone-hurehu, and Te Whakarau. This was the second great *heke* from Taupo, but no particulars are available regarding the first (called Rua-mai-oro). At Patea the following tribes sent men to swell the numbers: Ngati Whiti, Ngati te Upoko-iri, Ngati Tama, and Ngati Tu-whare-toa. Then this great body journeyed down the river together till they came to Kai-inanga, where they spent some time making canoes to convey their provisions down the Rangitikei River.

On leaving Kai-inanga some of the party went by land, and others with the canoes. Following the course of the canoes, the first day they came to Pounga, where they camped, next day reaching Otara. "Here," said the old man who gave the narrative, "we found no persons living, for the place had been abandoned for fear of witchcraft, by which many had died. We found bodies hung up in trees three and four together, and the survivors had scattered. We instituted a search for them, and on the Rangatira we captured thirty-one prisoners. We found O-tama-kapua, Te Weio, and Te Tai-nui, and the principal men caught at these places were Potaka and Te Rangi-tahua. This latter afterwards died by witchcraft, just as the others had done before him.

"Starting down the river from Otara, we reached Whaka-poka, and camped there, Ngati Hau-iti accompanying us. There we found a small pa, where some of Ngati Hau-iti were dwelling, and cultivating the land. Thence we reached Ma-karaka, and camped there for a time, finding people of the same tribe. Next we reached Te Mahoe, and then Te Pohue, where we camped at the mouth of the Pou-rewa Stream. There we divided, sending scouting parties to Oroua on our one side. and also in the opposite direction. One party came back the same day, bringing four people that they had captured, and next day our two reconnoitring parties returned bringing two more."

According to another account, the day after these two prisoners were taken, a strong division of the *heke* struck the main body of Ngati Apa between the Rangi-tikei and Turakina Rivers. Here a battle was fought, in which the Ngati Rau-kawa were victorious, many of the Ngati Apa being killed, and their chief leader Ta-whiro captured. Then, at the feast in honour of the victory, all the dead bodies were brought into the camp and piled in a heap. On top of this ghastly pile the unfortunate Ta-whiro was bound, stretched, and then flayed alive by a lady named Pekenga, eventually being killed by Tanguru, who was of the Ngati Hau-iti, Ngati Whiti, and Hine-manu tribes. Then the combined tribes set to work, the ovens were kept at glowing heat, and the Ngati Apa required no further burial.

Continuing this narrative the old man said, "After Ta-whiro was killed we left Pou-rewa, passed Parewa-nui, and pushed on to the mouth of the Rangi-tikei River. As a gale was blowing, we hauled up our canoes and marched down the beach, only one canoe venturing out, and reaching Manawa-tu. When we reached this place we camped for the night, and, as the gale was increasing, we hauled up the one canoe that had reached us, and left it on the beach. Then we continued our march along the beach to Kapiti, where we saw Te Rau-paraha and Te Pehi. We stayed there about two months, while our leading men went on to Poneke to bring up Taiaha, of the Ngati Ira, and his people; and while they were away we captured several prisoners at Horo-whenua, among whom were Te Kowhai, Hunia's mother's brother, and a woman named Whaka-haunga, of the Mua-upoko. After some time we commenced our return journey to Taupo, by way of the Rangi-tikei. We came to Parewa-nui on that river, and there baked karaka-berries. Next day we commenced to eat the berries, and made ourselves very ill, like drunken men. We found no inhabitants there: if there had been any at the pa we should have killed them.

"Leaving Parewa-nui, we reached the mouth of the Ranga-taua, and camped there. There died that night the daughter of Te Heuheu and a Tu-whare-toa chief named Te Poka. We believe that they were bewitched by the Ngati Apa." [As a matter of fact, they both died of wounds inflicted during a skirmish with a stray band of Ngati Apa. Huru-hia was the lady's name, and she was famed for her extreme beauty. A great tangi was held over her remains, at which Te Heuheu caused her head to be preserved, he himself calcining her brains, and strewing the ashes over the land, which he declared to be for ever *tapu*.]*

"Leaving the Ranga-taua we marched to Wai-tuna, and halted there while the heads of our dead were properly preserved." [Wai-tuna was a pa about two miles above the Onepuhi Bridge over the Rangi-tikei River.] "Some of our party who were going overland captured prisoners at Oroua. We were travelling in such a manner as to catch anybody in the neighbourhood. Here at Wai-tuna our party from Manawa-tu joined us, bringing in one prisoner. Here we again divided into parties, some going up the Turakina Valley and the others remaining near the Rangi-tikei. The first-mentioned party took several prisoners, but we took none.

"From Wai-tuna we went on to Ma-karaka (at Kaka-riki), and from thence to Whaka-poka; from there on to Te Kiekie (Makohine), and from there to Otara. At this place we found Te Waha and Te Rangitahua. who had returned and resumed residence there, for the priest had exorcised the spot. Then we went on to Kawatau (a river on the east side of the Rangi-tikei, above Manga-weka), where we stayed for some time, as we buried the bodies of Te Poka and Heuheu's daughter there. From thence we proceeded to Kai-inanga, where we left our canoes, and continued on our way to Taupo."

This journey, as described by our Maori friend, was called by him the "Heke Kariri Tahi" (migration of one cartridge), from the circumstance of their having very little ammunition. According to Travers, Whata-nui accompanied this *heke* for the purpose of conferring with Te Rau-paraha; but, finding that chief absent, he returned to Taupo almost immediately to bring down his people. From the manner in which these strong armed bodies of men roamed over the Turakina, Rangi-tikei, and Manawa-tu districts, killing and making slaves of all the unfortunate Ngati Apa they met, one can form an idea of the state of the country at that time.

We have notes of two later Ngati Rau-kawa *hekes*, one of which came down before the fight known as Hao-whenua, and the other immediately after; but. as the first of these mentions the death of Taka-rangi at Kohuru-po, that event had better be related first, as well as civil and other troubles related by the Ngati Apa themselves.

Now, there was a battle fought at Tara-kite (near Rata), called Tawapara, and after this Rangi-whaka-pou was murdered by Ika-whaka-ariki, both of Ngati Apa. To revenge that murder, the Kauae, in conjunction with Ngati Kahu-ngunu people, destroyed the whole hapu of Ika-whaka-ariki who were living at Huaki-tae-ore, across the Rangi-tikei, and at Rua-puta-uaki and O-weta-ra, down by the river (near Bull's).

When that war-party of the Ngati Kahu-ngunu came down to smite Ika-whaka-ariki, that chief fled to Whanga-nui, where he remained for some years, and when he thought he could return in safety he did so, and again took up his residence in his pa (below Bull's); but members of the Ngati Kahu-ngunu Tribe were still on the scene, and the Kauae people soon learned where Ika-whaka-ariki was hiding, and also his friend Orehu. So a raid was organized, and Ika-whaka-ariki captured without much trouble. When brought face to face with his captors he sang a song, and otherwise shewed his bravery; but this availed him but little, for very soon he had to go the way of all flesh, and trod the dim and distant road to Hawaiki.

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* In Travers's "Life of Te Rau-paraha" this lady's name is given as Reremai, but his informant was apparently in error, for Reremai was one of the victims of the Kai-inanga fight.

It was about this time that Rangi-iki-iki, after the death of his wife Kara, went away to Oroua, and Rangi-tuhaha went to reside at Te Whaau-rongo (near Halcombe).

The next affair that happened was the bewitching by Rangi-te-muri, which caused the death of a great number of Rangi-whaka-po's people, also many of the Ika-whaka-ariki and Kauae. They were all living at Paewa, and very often went to the mouth of the Rangi-tikei River fishing, when they would send large supplies of food to their own places, and also to Rangi-iki-iki (at Oroua). Rangi-te-muri noticed this, and set about bewitching the track which they had to pass over.

"It happened this way," said my informant, when telling of the event: "This man Rangi-te-muri lived on the flat in front of the present Parewanui Schoolhouse, and the old track lay between the two swamps, where the road runs at present. Now, Rangi-te-muri looked out daily and saw the people passing and repassing with their loads of eels and fish, and, although they passed his door, they never gave him a present or left any of the fish hanging at his place. Then said Rangi-te-muri to himself, "I'll fix them." And fix them he did, for he bewitched the track, and next time the fishermen passed that way (and they had to go that track, for there was no other) they travelled over it for the last time, and they received the punishment which was always meted out to those who touched bewitched things, and went to join their great ancestress, Hine-nui-te-po.

When Te Kai-whaka-taha saw so many of his people falling under this potent spell, in fear of his life he fled across the river, where he fell into the hands of a party of Ngati Kahu-ngunu who were on their way to make war with Ngati Apa. They quickly captured him, and, as he was a man of great avoirdupois, they made game by exhibiting him round, on account of his immense size and fatness. He was then duly killed and eaten, and the spot where the feast took place was named, in honour of the event, Tapu-iko-koneke—meaning "the fat thighs of the quail."

After this, Rangi-tane came into the Rangi-tikei district, accompanied by Ngati Tauira. They went to Wai-tata-pia (now the homestead paddocks on Mr. Dalrymple's run at Parewa-nui), a pa to the west of Rae-tihi (a sand-ridge on the same farm), and there they fought with Nga-riki and Tupa-taua. They were victorious, and, after having slain the chief Te Umu-o-te-hau, they went on to Te Awa-mate Pa seeking further quarrels. Nga-riki, after the loss of their chief, fled up the river. Then Hori Kingi sent two chiefs across the river, with full instructions to fetch some *poha tuna* (extra fine eels—*i.e.*, the chiefs) home with them from Puke-puke Pa (a fortified pa on one of the lakes lying between the mouth of the Rangi-tikei River and Foxton, known to local residents as Humpy's Lake), held by Ngati Apa; but warning was sent, and the two chiefs Rangi-hau-tu and Ao-kehu went out with a party and waylaid Rangitane, who were one hundred strong, and cut off almost the whole party, as out of that strong *taua* Te Weta was the only man who escaped. This battle was known by the name of Tu-raki-awatea, and was fought on the site of the Turakina Railway-station. The Tu-raki-awatea Pa stood on the other side of the main road, near the Turakina Bridge. The old pa on the opposite side of the river was known as Kopiro. Flushed with victory, the Ngati Apa followed up another party of Rangi-tane to Papa-rata (Oroua Downs), and annihilated them there. These losses naturally aroused the *riri* of the Rangi-tane, who obtained aid from the Ngati Kahu-ngunu, Nga Pakapaka, and Nga Mutu-ahi, from Dannevirke, and came against Pukepuke, but were again repulsed. Then they resorted to stratagem, and made it appear as though they had retired; but not so—they were simply hiding. Then some of the Ngati Apa women and children went in a canoe over the river on to the flat to suck flax-blossoms, and before they discovered their perilous position they were captured. In this way Oko-rewa, Te Hakeke's mother, was taken, as well as others; but before Rangi-tane got away with their prisoners, one of the women managed to call out to Rangi-hau-tu to follow, as his wife was a captive. He did so, but did not come up to the retreating *taua* till they came to the Manawa-tu, where, instead of fighting, a peace was patched up, and Rangi-hau-tu was returning home in full confidence with the women, when he was set upon by his escort of Rangi-tane men, and cruelly murdered by Taka-wai. His body was left on a ridge called Te Ruahine (a sand-ridge lying between the fertile and waste lands on the southern side of the Rangi-tikei River), but the women and children got back to the Pukepuke Pa in safety.

A Waiata composed on the Occasion of Rangi-hau-tu's Death, sung by a Rangi-tane Woman of the Pakapaka Hapu (mo te Matenga o te Rangi-hau-tu i patua e Taka-wai me ona taina ki te Ruahine Manuka).

Me whakawai hoki e puanga akohu te patu tonu ai,
Ka rau-ai to ringa mo nga ringa kino
Kai te Ruahine mo Tanitia* tena kei roto mo te rangi Whititua,*
Tena kei roto mo te Rangi-tapu-ihi,*
Tena kei roto mo taku roraruhu kai Pukepuke,
Mo te rorotuna ki Kai-kokopu,
I me kata atu au e hika i konei i.

—*I waiatangiu mai mo te Hakeke i te whawhai ki kahutara.*

"So died the great chief Rangi-hau-tu (storm-wind standing in the heavens) by treachery foul and dark. The proud canoe was broken up, and his people were left stranded, with the raging sea all around them, but they were not engulfed"—for Ao-kehu quickly sent messengers to Whanga-nui and Manga-whero, telling them what had happened, and seeking aid, which was readily given; and the combined forces travelled to Manawa-tu, where they defeated Rangi-tane at the Harakeke Pa with great slaughter. (The site of the Harakeke Pa was the place now known as the Sugarloaf Hill, below the Manawa-tu Railway-bridge.)

When this pa was first surrounded, word was hurriedly sent to Te Ahuru-o-te-rangi, who was then on a visit to the South Island. As soon as he received the message, he crossed over the Rau-kawa Strait with his war-party in canoes; but by the time he arrived the pa had been captured, and many of its people killed and eaten. Te Ahuru-o-te-rangi then

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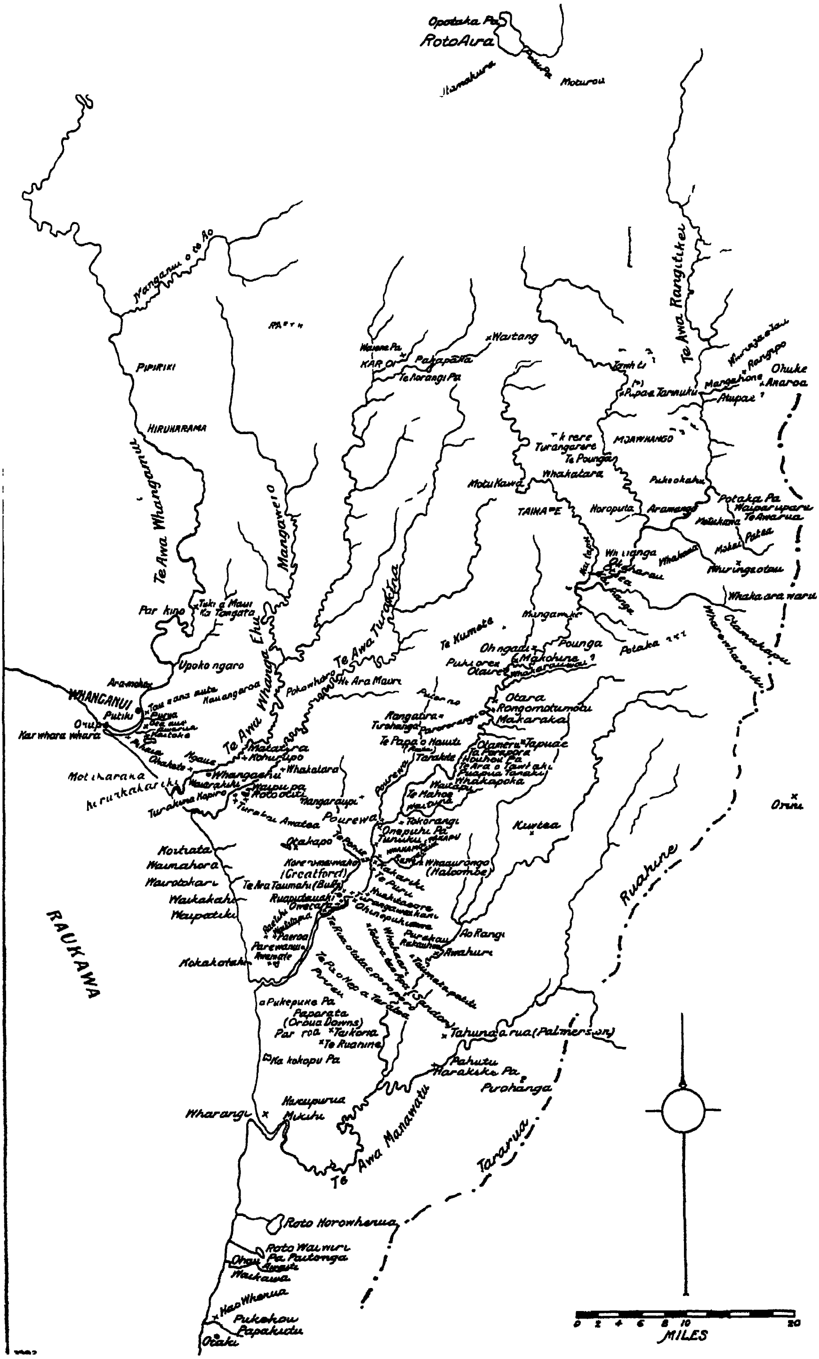
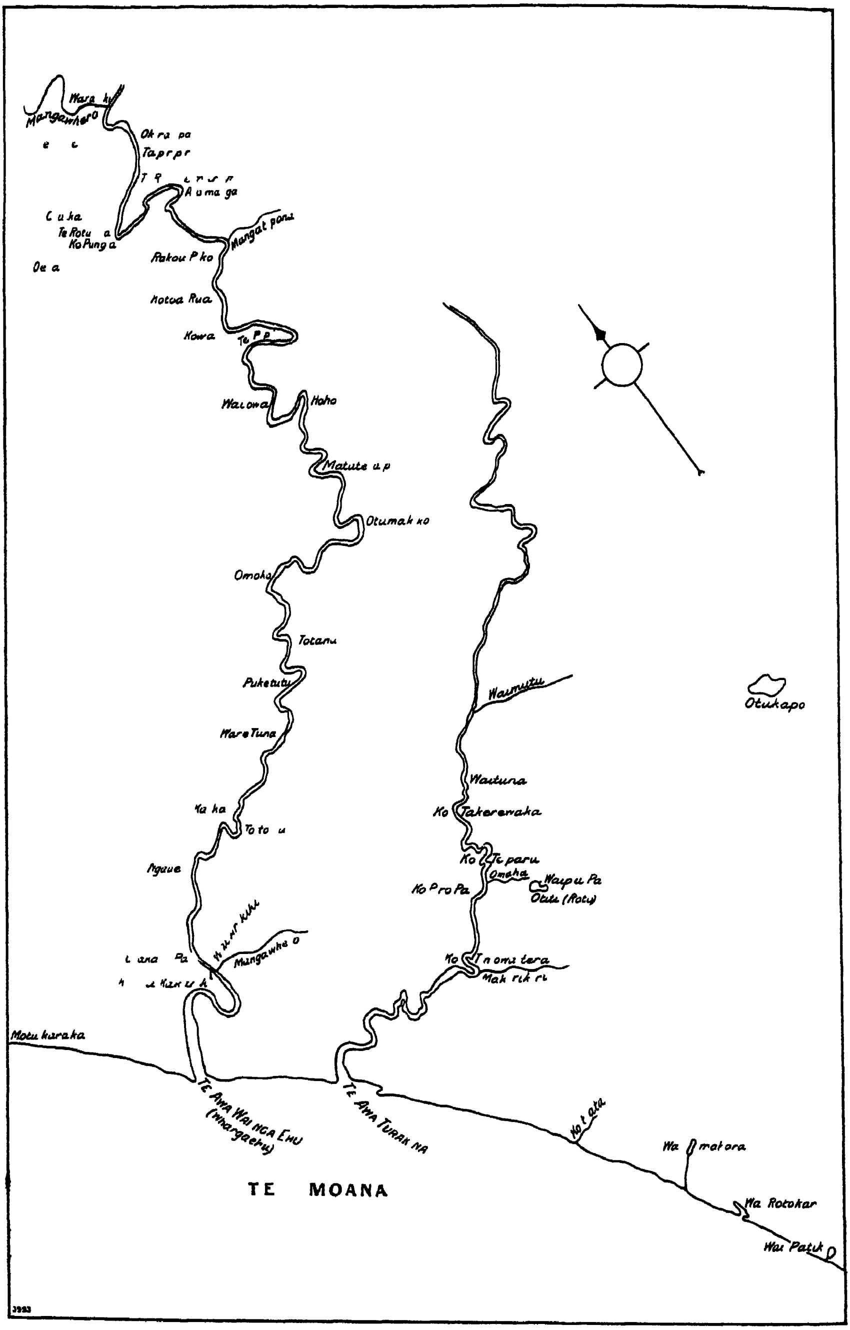
* Three Ngati Apa men killed previously.

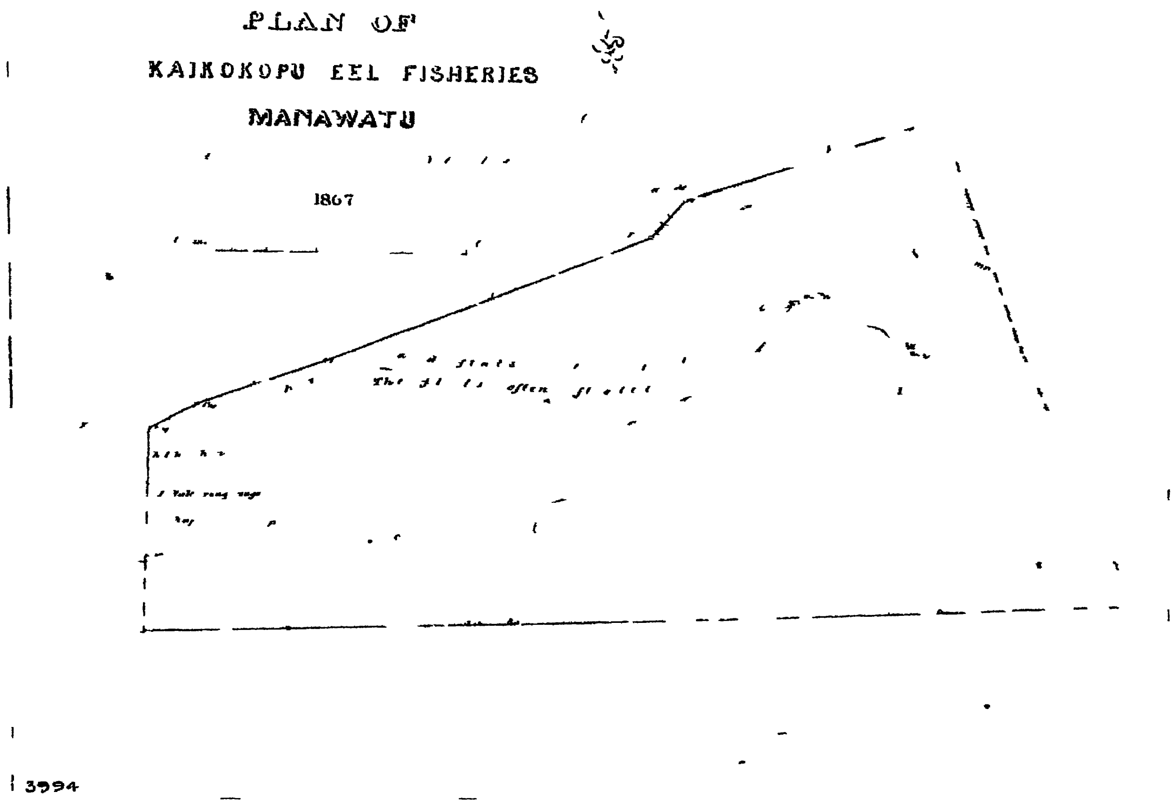


MAP ILLUSTRATING EARLY HISTORY OF RANGITIKEI.—Downes.

Face p. 96



MAP OF LOWER WHANGAEHU AND TURAKINA VALLEYS —Downes



REPRODUCTION OF AN OLD PLAN OF KAI KOKOPU LAKE.—DOWNES.

gathered all his people and attacked the Waipu Pa (on the Turakina Lake, the Maori name of which was Otiti: it lies on Mr. Lethbridge's property, about three hundred yards from the railway-station), where the Ngati Apa were expecting and awaiting the inevitable attack: but the pa was a strong one and its people many, consequently it withstood the siege for a long time, and eventually Te Kahu-te-rangi, who was related to Te Ahuru-o-te-rangi, came to Waipu and made peace, after which the various hapus in the pa returned to their own homes. So ended the trouble in this quarter for a time; but only for a very short time, for Ngati Apa next joined forces with Nga Rauru (Wai-totara Tribe), and, for some real or fancied injury in connection with Rangi-hau-tu's murder, they successfully attacked Pihaia, a pa on the sandhills between Putiki and the sea, on the Whanga-nui River. In payment, Whanga-nui travelled to Whanga-ehu, where they captured a large pa named O-hake-to, near the beach at that place, and here they killed O-take-hoke and others. Smarting under the defeat, a woman of the Ngati Wairiki went to Hawke's Bay to get help to revenge her people. When she reached Wai-rarapa she collected forces and returned, and her reinforcements joined with the men of Rangi-tikei, Turakina, and Whanga-ehu, and came on to the pa Tuke-a-maui, at Pari-kino, on the Whanga-nui River, which they besieged. The top end of the pa was defended by Manumanu's descendants, and the middle by Ma-ruru. The pa was surrounded and eventually taken, but the part which the Manumanu people were defending was not attacked.

Sam Woon, a well-known Whanga-ehu Native, has in his possession a *mere pounamu* taken by Ngati Apa at the fall of this pa.

Seeking further details regarding this fight at Tuke-a-maui, the writer was told the following interesting story by the grandson of one of the chiefs who took part in the attack:—

"Some of the Ngati Apa people were badly beaten by Rangi-tane at Pohangina, and among those who were taken was a Ngati Apa chief named Te Ahuru." [Te Ahuru was the man who, with his wife, arranged the attack on the Kai-inanga Pa, as related some few pages back. He was afterwards killed at Kapiti, when the combined tribes made their unsuccessful attack on Te Rau-paraha at that place. (An account of this attack has been published in the Jour. Polynesian Soc., so will not be further referred to here.) Details relating to the death of Te Ahuru's daughter will be related later on.] "However, in their eagerness to make this man a prisoner, they allowed some of his men to escape, who immediately fled away to Rangi-tikei, where they raised a party to seek revenge.

"Now, Rangi-tane, having captured Te Ahuru and others, kept them for a few days, and then set them to work to carry stones for the *umus* in which they were to be cooked. After enough stones had been gathered, they made the unfortunate men gather firewood for the ovens, then the leaves, and, last of all, they forced them to dig out the *umus*, and when all was ready the conquerors lined up for the *haka* which was to celebrate the victory; but, in the middle of the song, down came Ngati Apa—the party that the recent escapees had brought along. They smote left and right, and before many minutes were over the ovens were steaming, but they contained Rangi-tane instead of Ngati Apa.

"Te Ahuru was doubtless well pleased at his release, but he desired still further revenge. So he sent messengers to Wai-totara and Patea asking the Nga Rauru to bring *kai* and send men. The northern Natives heartily responded, sending two hundred fighting-men, besides many slaves bearing great quantities of the indispensable *kai*. When they came to the Whanga-nui River, Taka-rangi, the great Whanga-nui chief, who was afterwards killed at Kohuiu-po, heard that the Nga Rauru people were in his territory, and he said 'What are these people doing here? I will not allow them to carry food over me.' So he sent out his men, and after a short skirmish Nga Rauru retired minus their *kai*. When Ngati Apa heard that Taka-rangi had intercepted those who were coming to give them assistance, they immediately started out, and took a large pa situated on the Kai-toke Lake" [about two miles from Whanga-nui No. 1 Line]. "Whanga-nui, not to be outdone, travelled to Rangi-tikei, where they besieged the pa at Pou-rewa, killed Te Haha-o-te-rangi, and then retired.

"Then up arose Te Ahuru and said to his people, 'I hear there is a brave man called Te O-raunga of the Mua-upoko. I will go to him and see if he will lend a hand to help punish Whanga-nui and Rangi-tane.' So he went to Wai-were, a pa at the south end of Lake Horo-whenua, and laid his views and intentions before Te O-raunga; but that careful chief said, 'No, I am afraid I cannot help you, for this *taniwha* you wish to destroy has two heads—*i.e.*, Whanga-nui and Rangi-tane. If it had only one I would willingly go. But go on to Pori-rua. Te Huke-o-tungia is there, and he will assist.' So Te Ahuru went to Pori-rua as directed, but Huke-o-tungia said, 'No, I cannot help; but let us go to Nga-kaka-waha-nui (the loquacious parrots), at Wai-rarapa.' So they went on, and came to the pa" [near Mr. Bidwell's], "and there they found the two kakas famed for their great beaks, Te Whata-horo and Te Kaka-hou, and explained what they came for. After hearing all Te Ahuru and his friend had to say, the two great chiefs replied, 'Yes, we will help you. Go home as fast as you can, gather all your people, and plenty of *kai*. We will follow in a few days.' So Te Ahuru returned to Rangi-tikei; but as soon as he had gone, Whata-horo said to his friend, 'Had we not better follow, at once, before Whanga-nui hears of our approach and has time to gather?' So they started off from Wai-rarapa with a great army of over three hundred men of the Rakai-whaka-iri, the Ngati Kahukura-a-whitia, the Hamua, and the Ngati-moe tribes, all branches of the Ngati Kahu-ngunu.

"When Te Ahuru left Wai-rarapa he arranged with his own people to have supplies of food ready, and with this purpose in view he came on to Whanga-ehu; but no sooner had he called his people together than a great war-party was seen approaching from the south. The people were much afraid, and said to Te Ahuru, 'What is the meaning of this?' Te Ahuru, although he felt considerable apprehension, replied, 'Perhaps it is our friends from Wai-rarapa and Pori-rua. Let us go forward to meet them.' (The Pori-rua people had also joined, although they had at first refused.) So the two parties met, and the apprehensions of the Ngati Apa were quickly set at rest by the joyful discovery that the *taua* was led by their Wai-rarapa friends. After the customary feast had been disposed of, a war-dance was executed, during the excitement of which some of the brave fellows advised going on to Whanga-nui that night. Te Ahuru opposed this, for he wished to have time to gather all his available Ngati Apa force. But Tui, the *tohunga* travelling with the *taua*, settled the dispute by saying, 'We will go now, for even at this moment the Whanga-nui people are preparing to resist us, and to-morrow we will meet their party and be victorious.'"

THE PROPHECY BY WHICH TUI EXCITED THE TAUA TO GO ON.

Tera ia te ata taua Takiri ana mai.
Kai Tongariro e, ko te mamaru,
E whakakaka ra i ona rau,
Kia riro mai ko Tu-kapua
Kai riro mai ana ko Huru-tara
Kia whakatauria iho te kohu ka kikimai
Ka titiro he ure ngorengore no Pakihi
No muri ka whati te piki
No tura kai te awatea,
Kua moea e au ki te po
E tu ana Kai-whara-whara
Ka nunumi kai Ota-aue
Kia tangi mai to karoro, aue!
Taku kai he piro tangata
E he wai ka kato te wai o Whanga-nui
Kai u kei uta ka huri Taikoria
Ka huri ki Waiwiri
Hara-mai a i ona rau
E rua, ki au kakari ai e
Ruru e, Ruru e, kai taraha e i.

[TRANSLATION.]

Lo! the morn of wrath is dawning.
At Tongariro the hundred are being
Incited to defeat Tu-kapua and Huru-tara.*
Enveloped by the mist they will assemble
For the fight. They will look on us with disdain,
Unworthy to fight against; but they will be
Defeated at daylight.
At night I dreamt—I beheld
Another victory at Kai-whara-whara.†
They were also overwhelmed at Ota-aue,‡
Causing the sea-gull to scream, "*Aue!* alas!
Oh! my meat is the stench of human corpses."
Held back is the wave of Whanga-nui
Lest it should overflow Taikoria
And also flood Waiwiri.§
The hundred attacked me in vain.
Two to one against me, I defeated them,
And glorious was my victory.

So they started off that night, taking the road by the sea-beach, and just as day was breaking they ran right into the Whanga-nui war-party at Kai-whara-whara (the South Spit, Whanga-nui River). Still under the excitement of the recent *haka*, the invaders made short work of the surprised Whanga-nui-ites, and before very long the pair of kakas with great beaks were counting the spoil. They made a pile of the dead men four high, laying them crossways as children cross and recross their hands in play. "How long the row was," said my informant, "I don't know—perhaps a mile, perhaps less—but, at any rate, as soon as the wall was built, Whatahoro and his companion said to Te Ahuru, 'Here is payment for you. Is it enough?' and so they gave the whole pile to Ngati Apa as a *hakari* for them. While the feast was going on, Tui, the *tohunga*, got up and sang another song, in which he described other places that would be taken, and told the names of the chiefs to be killed. So the party, taking his good advice, advanced, bent on mischief. They attacked the pa Ota-auo" [on the Awa-rua Creek, about half a mile below Putiki], "where they captured all the inhabitants, and sent them as slaves under escort to Rangitikei. Then on again they went, determined to take the large pa at Parikino named Tuke-a-maui, which was known to be full of people. It took the war-party several days to effect an entrance, but they eventually dragged down parts of the palisading by tying flax ropes to the middle of short pieces of wood, throwing them over, and then pulling. After this victory the war-party retired, carrying with them many slaves, and satisfied that at least one of the *taniwha's* heads had been considerably damaged. The old pa Tuke-a-maui stood on the rising ground above Kai-tangata, the old name of the pa now known as Pari-kino. Pari-kino was a pa on the cliff side of the river, opposite Kai-tangata.

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* Tu-kapua e Huru-tara—Men of the Wai-rarapa *taua*.
† Kai-whara-whara—South Spit, Whanganui River.
‡ Ota-aue—A pa on the Awarua Creek below Putiki.
§ Waiwiri—The lake usually known as Pa-pai-tonga.

"Now for the other head: Flushed with their recent conquests, Te Ahuru now decided to give his friends a skirmish with Rangi-tane; so he again gathered his Ngati Apa force, and, joining with Wai-rarapa, they marched away, having previously sent out spies, two by two, who were to hunt the district, and let the main body know where the most people had congregated. Soon the scouts returned with their report to Orini (near Tahora-iti), which the *taua* had now reached, and informed the leaders that all the people in the district had vacated the small pas and fled to Rai-kapua, a strongly fortified pa on the Upper Manawa-tu River, having a high inaccessible cliff immediately behind it. So the war-party laid siege to this pa, and carried on the operations with such fury that in a very short space an entrance was gained, and the slaughter of the defenders commenced. Altogether two hundred poor wretches were killed, and one hundred taken as slaves; and again the dead were piled up in a row four deep, with the captives on top. Then said Whata-horo to Ahuru, 'There is your second payment. Divide this pile into two equal parts, and bind the dead on the shoulders of the living.' So he gave half of the captives to the Ngati Apa party and kept half himself, and the two tribes separated, each forcing their slaves to carry home their dead comrades, who were no doubt destined to grace the board at the first feast. Thus was the *taniwha's* second head destroyed. The descendants of the slaves captured on that occasion are still to be found at Pori-rua and Wai-rarapa."

KO TE MATA TENEI A TUI, MATENGA I TAHURI AI RAI-KAPUA.

[Tui's Song before the Capture of Rai-kapua.]

Takoto paranga he matuku
Takoto paranga he matuku
Ka whaterotero mai te arero huare ki waho
Hora ana te huruhuru o tona ure
Te hokinga mai o te Parekura i te koru ra,
Aha ha he pane whiti, aha ha he pane taonga,
He niho tete mai i runga o te turuturu,
A taina a he aha ka nene ka tangi koe e.

This *waiata* is a vision and a prophecy as to what the result of the assault on Rai-kapua would be.

After this, a woman of rank belonging to Ngati Wairiki was killed near Turakina by Ngaiti Whiti, so Tama-te-kura collected people from Whanganui and Manga-whero to avenge her death. The party travelled to Rangitikei and took a pa called Toko-rangi (Whanga-ehu), where they killed the chief Poa-tawa and a great number of people, and after the usual celebrations returned home. After this Tawhero-haki was killed in retaliation;

consequently Pehi Turoa, the great Whanga-nui chief, went to Manumanu's relatives and said, "We must have payment for this man's death." So they gathered a force, and went to seek revenge at Muri-motu, where they killed Tama-te-kura, Te Kahu, Toetoe, and others belonging to Ngati Tu-whare-toa. They afterwards had another fight at Tiki-rere, where more people of this same tribe were killed. And so the quarrel went on; but, as the complicated law of *utu* entailed fighting among various tribes outside the Rangi-tikei district, these quarrels need not be followed further.

After this, more civil trouble arose owing to one of the Kauae people named Te Hina beating and otherwise ill-treating his wife. She objected to this, and fled across the river to her people to complain. They were angry with Te Hina for this, and to square matters they took from the woman a famous *tiki* belonging to her husband; and when she afterward returned without the *tiki*, he bethought him of ancient grievances (although up to this time Kauae and Maero had lived together as neighbours), and remembered the annihilation of his people by Rangi-te-muri; so he gathered some of his people, made a raid, and captured Maero, Tau-iri, Te Hanea, Mokomoko, and Pauhu, as well as many others. He also recovered his *tiki* and other property, and, to properly punish these people for taking his wife's part, or else taking his *tiki*, he made a great fire and scorched his prisoners over it, in much the same manner as eels are treated for fattening. (It was an old-time custom with the Maoris on this coast, when on an eel-fishing expedition, to gather together all the small and skinny eels caught, and then light a fire of fern down by the water's edge. Then the contents of the *hinaki* were emptied into the middle of the fire, and it was supposed that by this persuasive treatment the unfortunate eels that managed to crawl through and reach the water would eventually grow large and fat; and who would doubt it? This custom was called *Tunutunu ki te ahi.*)

After the burning, Te Hina had his prisoners liberated and sent them away, and, as they were his wife's relatives, he acted kindly, and did not kill any of them except Pauhu; but they resented his kind treatment, and immediately commenced to make plans for avenging their insult. First they commenced going to Oroua, but eventually decided to go to Awa-mate. Soon after settling there they received a visit from a chief named Tama-whi-rangi, of Ngariki, who was connected with Maero, but who was also related to Te Hina. Him they took and killed as a first blow in revenge for their burning. When Te Hina heard how his relative had been received at Awa-mate, he left his pa at Tu-nuku, above Kara-riki, and hastened with a war-party to revenge that death; but he was himself killed, and his party driven home. When Wai-tene heard that Te Hina had been killed, he sought assistance to punish Maero, and was aided by the Muaupoko, Ngati Kahu-ngunu, Nga-wai-riki, and other hapus of Ngati Apa. This large force attacked Te Awa-mate, which was an island in a lake, but did not take it, not having canoes.

(The Awa-mate Lake is a long, narrow body of water, curved round something after the shape of a horse-shoe, lying on Mr. Dalrymple's property at Parewa-nui. When the writer first saw it, many years ago, the island referred to had a peculiar appearance, owing to a number of trees standing with their roots upwards—the remnants of ancient fortifications, called *puwhara*, upon which platforms were built. The same thing was noticed at other places when we were children, but not to the same extent; but these, like many other objects of which we then took but little notice, have long since disappeared.)

Finding they were unable to take the island, the war-party retreated. but almost immediately returned to the attack, and on this occasion they killed Kakaho. the daughter of Te Ahuru, and others; but again they were unsuccessful in taking the pa, and so again they retired.

"The murder of this poor girl," said my informant, "was a very discreditable act"; and while he gave the following details, the old man's eyes filled with tears.

Before Te Ahuru went to fight Te Rau-paraha at Kapiti he had a presentiment that he would be killed at that battle, for in a vision (dream) he had seen his own head fixed on the top of a pole; so he gave to his daughter his *mere pounamu* called Te Rito-harakeke (young blade of the flax), with the instructions that she was never to part with it, and also that she was to wear it night and day, but in such a manner that the cord which held it round her neck was to be kept concealed beneath her mat.

When the poor girl was captured at Awa-mate, her captors formed a ring round her, and she was ordered to sit down in the enclosed space; but she refused, and said, "Why should I sit down to be killed? Allow me to stand and sing my death-song. after which I will be ready." Then she asked Te Kahawai to give her his mat so that her body might be covered after she was dead. and Te Kahawai without a moment's thought complied with her request and laid down his *mahiti* (dog-skin mat) on the ground before her.

While she was singing Te Kahawai noticed the tears trickling down her cheeks, and when the tangi was finished he said to her, "Why were you crying just now?" Kakaho replied, "Do you ask me why I was crying? If you were a woman, as I am, you would know very well why I was crying." Continuing, she said, "I, like you, am going to be a fish of the sea, for I am a woman of much blood; and may this thought carry you to death, for you are not a man of your word." (Some reference to the fact that the *kahawai* fish. when caught, bleeds more freely than any other fish known to the Maori.)

Then one of the party took a *tokotoko*, and. giving it to another chief, he said, "Kill her with this." Kakaho overheard the order, and immediately cried out, "Let me not die by such a mean weapon. If die I must, kill me with this." And as she spoke she drew from her bosom the *mere* Te Rito-harakeke, and held it aloft. The man who had the *tokotoko* seized the *mere*, calling out, "Yes, it is a good weapon, and a good girl," at the same time striking her a blow that laid her low for ever.

Then it was noticed that her body was *tapu*. being protected by the *mahiti*, which by this time was wet with blood welling from the death-wound; consequently she was not eaten, but buried as befitted a chief's daughter.

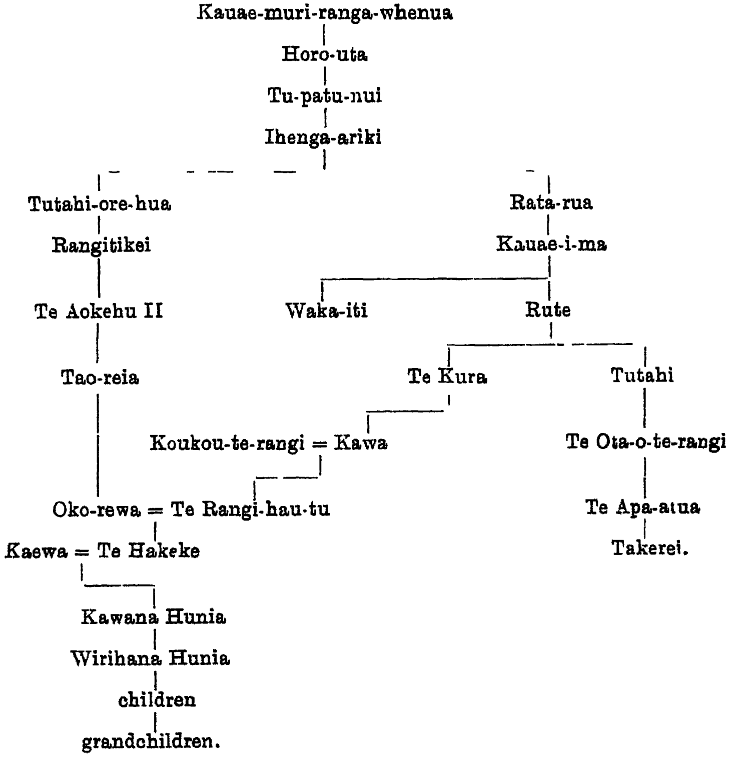
As soon as it was discovered that the girl was dead, Te Kahawai turned to Paihure. the man who had killed her, and said. "Why did you kill her in defiance of my protection?" and, receiving no satisfactory answer, he took the *mere*, and Paihure also fell to the ground, a dead man.

After the siege, Maero and Tau-iri were so worried by the appearance of the Ngati Apa almost daily, and also by the shortage of their food-supply, that they determined to evacuate the pa and go to Ao-rangi. So they quietly left Te Awa-mate and went to Oroua; but the Ngati Apa people followed them up and killed several, but the chief person killed was a woman named Hiango. and she was killed by Wai-tene. After this the Maero people resolved to scatter; so Hura, Rihi-mona, and Rene-hura went to Horo-whenua for safety, the others all going to different places.

CHAPTER V.

Now, when Te Hakeke grew up he desired to obtain further revenge for the death of his father Rangi-hau-tu; so he went up the Rangi-tikei River and conferred with some of the chiefs there, with the result that a war-party of the Tupa-taua and Nga-riki hapus journeyed to Manawa-tu, where they surrounded the Pahutu Pa (near the bridge at Palmerston North), at which place Rangi-hau-tu's murderers were living. The invaders were fairly successful in this little tribute to the dead chief's memory, for two of the chief culprits (brothers to Taka-wai, the real murderer) suffered for their relationship, and their spirits fled to the Rerenga Wairua (spirits' leaping-place), and Te Hakeko himself had the satisfaction of killing the man who had held his father down while he was being murdered. However, justice was not always meted out to the ill-doers in those days, as now, for the real cause of all the trouble, Taka-wai, escaped, and so the party had to return to their pas with the lust for blood in their throats only partially satisfied.

TABLE 7.—SHOWING THE ANCESTOR KAUAE, FROM WHOM THE SUBTRIBE TAKE THEIR NAME.



It will be remembered that after Te Hiango was killed, Rihi-mona, Hura, and others went to Horo-whenua for safety, and after a time the Mua-upoko people, with whom they dwelt, thought that Hura's wrongs should be more fully avenged, so they came with Rihi-mona back to Lower Rangi-tikei to make war on Ngati Apa. They arrived, and halted just below Parewa-nui, and sent out scouts to reconnoitre. The only person the scouts discovered was Kaewa (Te Hakeke's wife), whom they found with a companion gathering tutu-berries. She was uncertain whether she would be killed or not, but the scouts contented themselves by stating their object and asking for Hakeke, who was away at Turakina mustering a war-party to fight Rangi-tane. Leaving Kaewa unhurt, the scouts continued their search, and soon after found Ngoki, Kaewa's sister, who was surprised and killed at O-taka-po, close to where the township of Bull's now stands. As soon as Hakeke returned from Turakina, he discovered what had taken place, and made all haste to follow up the retreating war-party, and fell in with them accidentally at Wha-rangi (Manawa-tu), where they were busy in the swamps catching eels. Although thus engaged, they were working "with one eye open," for they judged by the flight of some seagulls that they might be surprised by a pursuing party; so Tu-ranga-pito was ready with a long-handled tomahawk, and Hakaraia was also near to bear the brunt of the attack, and these two sought to engage the enemy while the rest of the Mua-upoko drew together. Then Hakeke remembered that these people whom he had come out against were his own connections,* so he sought a truce, and to do so ran up and threw his dog-skin mat over Rihi-mona. Tu-ranga-pito was angry at thus being baulked of the excitement of a fight, so he tried to make trouble, and cried out, "Who is that *tupapaku* (dead body) you have there?" apparently endeavouring to excite them by reference to the late murder. But Hakeke seems to have been a man of peace, for, although Ngoki was Hakeke's sister-in-law, she was also a connection (*whaea*) of Tu-ranga-pito's. Notwithstanding Hakeke's command, Waitene (Ngoki's brother) still endeavoured to kill Hura and Rihi-mona, but was checked by the others. Eventually the Mua-upoko people crossed the Mikihi Stream, but while they were crossing some one called out "Ko Ngoki tonu"; but it was too late to cause further trouble, for by that time Mua-upoko were on the other side of the Manawa-tu. Hura and Rihi-mona never returned to Rangi-tikei.

After these things Pouhu was killed by some of the Nga Riki and Tupataua people. Pouhu, it will be remembered, was one of those who suffered scorching at the hands of Te Hina, but who recovered from his wounds. He was one of the Maero hapu, and he was killed by Tahataha and Marumaru in revenge for the death of Te Hina, who was killed in assaulting Te Awa-mate pa, and also in revenge for Tama-whi-rangi, the visitor who was killed at the same place. It may be mentioned that this tribe, the Nga Riki, was a *hapu toa*, Hakeke and all the other leading chiefs of Ngati Apa being connected with it. As *utu* for Pouhu's death, Hori-te-hania and his companions killed one of the Rangaranga-tu people at Oroua. He thought first of all that he would kill Te Haena, who was an old man of Nga Riki living at Totara-tae-apa (Sandon), but he did not carry out that idea, as he was afraid of Te Hakeke; so he went on to Oroua, where he killed Pokana, of the Rangaranga-tu hapu, but spared his sister, who was connected with him by marriage. This murder was, even according to Maori ethics, a very discreditable transaction (*he kanohi i pania ki te toto*). The next item was that the Ngati Apa sought revenge for this, and went to Hakupu-rua (Oroua), where they killed, of the Ngati Tauira and Ngati Maero, the following persons: Mokomoko, Roreopa, Te Rangi-ta-koru, and Tara-wehi, who was a daughter of Hura, and also her brother Tahu-potiki;

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* Kaewa, Te Hakeke's wife, was a Mua-upoko woman.

besides, there were a number of women taken prisoners, but none of them of any great name. Te Waitene wanted to kill Hura's two children in revenge for his sister Ngoki; but Rangi-te-ika, of the Nga Wairiki, would not consent to this; so they were spared, and sparing their lives saved further trouble on that occasion. But rest was not yet. Ngati Maero, Ngati Tauira, and Rangi-tane combined to attack Ngati Apa, so they came to Te Puru, near Kaka-riki, on the Rangi-tikei River, where they met their foe: but they also met defeat and disaster, for at that siege two of their leaders—namely, Umupo and Rongo-mai-tai—were killed; but Kakapa, of Tauira, and Ropiha Piriha, who were both captured, were spared. The leaders of the victorious Ngati Apa were Hura and Rihi-mona, who had come up from Horo-whenua on a visit, but who afterwards returned to their people the Mua-upoko.

It was about this time that Te Rau-paraha settled for the second time on Kapiti (Te Rau-paraha actually settled on Kapiti in 1824, but he came down the second time from Kawhia in 1821), and when he was established there he fought against Rangi-tane and afterwards against Ngati Apa. Then others of the Taranaki, Ngati Awa, and Ngati Toa tribes shifted down to Kapiti, so as to get out of the road of the Wai-kato and Ngati Mania-poto *tauas*. Some of these *hekes* went by the sea-shore, others travelled inland searching for food, so all the hapus along the coast stayed in their various places, but for a short time endeavouring to evade these migrating parties.

Rangi-tane and Ngati Kahu-ngunu now sought revenge for the death of Rongo-mai-tai; so, when Te Hakeke found that they were on the way to Turakina, he decided to gather all the available Ngati Apa together and meet the enemy there. With this purpose in view he hurried to Turakina; but before he reached that place he fell in with a *taua* from Whanga-nui, who were travelling by canoe to Kapiti, but who had landed on account of bad weather. They caught him, and carried him on to one of their canoes, where they held him down, endeavouring to kill him by cutting his throat with a shark's-tooth knife; but he strove with his great strength, made a gigantic effort, and threw them aside as little children, and so broke clean away from them; and then, when at some little distance, he called back to his pursuers, "I am Hakeke, the great Hakeke. You cannot capture me." They could not, although they tried; and Te Hakeke ran back to Rangi-tikei.

The Rangi-tane party went on to Turakina without knowing anything of this, and, as the Ngati Apa there had not received Te Hakeke's warning, they were quite unprepared. When the *taua* consisting of the Ngati Kahu-ngunu, Rangi-tane, and Mua-upoko hapus, under the chiefs Te Wheta, Te Aweawe, and Hori Kingi, in all 340 persons, were travelling down the coast to the attack, they were discovered by Te Wai-tene, who immediately warned his people. Only a small party of defenders could be raised at a moment's notice, but these few were angry and desperate men, and so, nothing daunted, Te Wai-tene, the brave and his six companions of the Nga Riki attacked that great combined army; but, although brave and strong, these seven were but as a few grains of sand before the whirlwind, and soon Wai-tene and his brother Te Hokinga were speeding to meet their ancestors on the dim shores of the spirit-land. But Hori-te-mohi and his elder brother escaped—all the armies of the world were not strong enough to take them.* This affair is known to the Maori as the Turaki-awatea fight, and it took place at Te Kopiri, near the railway-station, Turakina. After this, peace was made. Te Rangi-te-ika conferred with Mua-upoko and Rangi-tane, and they returned home; but on their way, when near Te Ara-tau-mahi (Bull's), their good resolutions melted away. The opportunity to kill some one could not be resisted. Was not the excitement of the fight the very spice and essence of expectance? So they killed Hatoa, of the Ngati Apa, at that place. The hue and cry was quickly raised, Ngati Apa followed them up, and at the Manawa-tu River they came upon them. There a skirmish took place, with the result that Pa-anga, of the Rangi-tane, and others were killed, though Te Weta, whom they were anxious to take, escaped up the river, though badly wounded by a spear-thrust in the thigh. (This was the same man who escaped on a previous occasion when attacked by Rangi-hau-tu and Ao-kehu.) Ngati Apa then returned home satisfied, having avenged both their late defeat at Turakina and the murder at Te Ara-tau-mahi (Bull's).

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* The spear with which Wai-tene was killed is now in the hands of Wiihana Hunia, of Otaki.

CHAPTER VI.

It seems to have been about this time that the battle of Manga-toetoe took place, in Hawke's Bay, between the Manumanu people and Ngati Kahu-ngunu, at Manga-toetoe, where Rewharewha and other chiefs of Ngati Kahu-ngunu fell, some thirty in all; and again they were defeated at Pou-taka, where the Ngati Apa and Koiri people killed Tua-whitu. For payment Ngati Kahu-ngunu obtained help from the Ngati Apa and Ngati Maru tribes, who assembled at Here-taunga under the command of Tangi-te-ruru, Roro, Rangi-nui-kapo, and Te Rei.

The combined forces then travelled to Mokai Patea, where they found Pokai-tara, of Ngati Whiti, living at Whiringa-o-tau; so they killed him, and then crossed the Rangi-tikei River, where they killed Te Rahui, who belonged to the people living on that side of the river. When Pehi Turoa heard that the Ngati Kahu-ngunu were in the Rangi-tikei district, he wished to assist them, so he and Kaeaea (usually known as Taringa Kuri), of Ngati Tama, raised a party and went to help. As soon as Ngati Wai-riki heard of this great army advancing, they sent messengers to Rangi-tikei, Whanga-ehu, Turakina, Manga-whero, and O-takapo, and raised a force to check the advance of the combined tribes, who had now joined. They met the enemy at the place where the town of Marton now stands, and, after a challenge to single combat had been given, the chiefs Kapia, of Ngati Wai-riki, and Rangi-nui, of Ngati Kahu-ngunu, met, and after a hand-to-hand conflict Rangi-nui was killed. Upon seeing the fall of their chief leader, the Ngati Kahu-ngunu lost heart and fled. In this battle, which was called Taku-te-rangi, the Ngati Kahu-ngunu numbered 1,600 men (probably greatly exaggerated, for our friend is speaking *à la* Maori), while their victorious opponents mustered only about 340.

After this the *taua* reconstructed, and went on to Here-taunga, whence they had come, still determined on mischief. When they arrived at Maka-roro (head-waters of Wai-pawa River) they found the Ngati Upoko-iri and and Ngati Hine-manu living there. So they attacked the pa and defeated its inmates, killing twenty-two of them. Some of the survivors from Pona-pona fled across the Wai-pawa River, where they rallied, and in turn defeated their enemy at Wai-pohue, Pou-kawa, near Wai-pawa (Jour. Polynesian Soc., vol. ix, p. 74), and killed Rangi-maona-ariki, one of the chiefs of Tangi-te-ruru's war-party. After this defeat Tangi-te-ruru hastily returned home.

The next item in the chain of events was another *heke*, which the narrator affirms took place before the battle known as Hao-whenua, which was fought at Pakakutu, near Otaki, in 1833 or early in 1834. The description of the journey was obtained from one of those who took part in it, as also was the previous one recorded. So the story may be given for the most part in our friend's own words.

"Wai-kato came down, a great migration of eight hundred strong. We came by way of Taupo, and joined the Turakina River at its head-waters, and were two days travelling down-stream. Then we struck over to the Rangi-tikei, and at Wai-tuna, on the farther side of the river, we caught Makere-rua, Moekau, and others of the Ngati Apa. Before this, when travelling from the Turakina Valley to Pou-rewa, at the mouth of the Manga-raupi, we found other people of the same tribe, whom we caught, and carried along with us to Kapiti. They were Tai-hapara and Mohi. Further on, at the Whaka-moe-takapau bush, we captured Tumata-whiti and others. They were busy preserving birds when we surprised and captured them. This man Tumata-whiti was a sorcerer. His own wife said he was an *ahi-taraiti*" [probably this word means "firelight": *ahi* = fire, *taraiti* = Maori mode of pronouncing "light"]. "So we killed him, and took the woman along with us. At Kiwitea we took Te Kiore prisoner; but Kaka-raia, Pouri, and others escaped. Afterwards, when we reached Kapiti, we released Kiore, and sent him back to assemble the hapu for the purpose of making an alliance with them. At Kai-kokopu" [one of the numerous lagoons lying on the sand between the lower Rangi-tikei and Foxton districts, about a mile from the sea, now known to sportsmen as Hunia's Lake] "Te Kiore found Te Hakeke, who acquiesced in the proposal. Te Kiore then came down the Rangi-tikei to Parewa-nui and other places. The tribes first met at Kai-kokopu, where the Ngati Rau-kawa chiefs met Te Hakeke, and the alliance was made.

"Soon after we commenced our journey down the Turakina Valley we came upon a hunting-party capturing and preserving birds. Of these we took ten prisoners, one of the principal captives being Amiria, the wife of Hirea. Also, at Manga-raupi, by the Pourewa Stream—that is, between the Tutae-nui and Pou-rewa streams—we took six more of the Ngati Apa, who were also preserving birds when we came upon them.

"We came out on to the river-beach Kokako-tahi, and travelled along the seaside to Otaki, from which place we sent a messenger back to Hakeke, who came and joined us, and after that came the fight at Hao-whenua. Immediately after that fight we returned to Wai-kawa, fifteen miles from Otaki, and we stayed there for some time. While we were living there we heard that Hakeke had concentrated the Ngati Apa at Parewa-nui, so we went along to that place and found a pa built, where a great number of the Ngati Apa were residing with Hakeke. We were then four hundred strong. Nepia's pa was on the other side of the Rangi-tikei, opposite to Parewa-nui. The Ngati Rau-kawa went into it and occupied it by force. This would be about the year 1830" [1833].

"We went straight on from Parewa-nui to Tu-rangi-wai-kani, on the other side of the Manuka bush inland" [an old pa on the flat below the Bull's racecourse]. "We went there for food, as the plantations of the Ngati Apa were very extensive. Tu-rangi-wai-kani was then a very large settlement, about the same size as Putiki of the present day (1875). We stayed there for fully a month, the prisoners we had taken staying with us. Some of them we had returned to their tribes previous to Hao-whenua.

"Coming up the river from there, we came to Te Ana and Te Karaka, at both of which places the Ngati Apa were living in force. From there we went up to Te Pohue, and stayed there for two years and a half. There were three settlements between these places, full of Ngati Apa, for they were a very numerous people in those days. The reason why we stayed so long at Te Pohue was that we had taken a great liking to the land in consequence of the abundance of kakas. A *whakatauki* arose from this—namely, 'Noku tenei whenua ko rangatira'; meaning, 'This my land is the chief of lands.' After we left Te Pohue we proceeded home."

This may have been the migration known as the Heke Mai-raro, or "migration from below," the north point being always referred to as downward. Another war is known as the Heke Whiri-nui, called by this name owing to the fact that the *whiri* or plaited collars of their mats were made very large for the journey. This is the name given by Travers, in the 'Life of Te Rau-paraha,' to the *heke* previously described, but called by the Maori narrator the Heke Kariri-tahi; and the Kariri-tahi migration is described by him (Travers) as having come down later, under Tara-toa; but we are inclined to think the account given by our dark friend is the correct one, though it is difficult at this date to be certain, for after Te Rau-paraha was firmly established in his newly acquired land these *hekes* were constantly occurring, both to help him and also to participate in his newly acquired wealth.

Regarding the battle of Hao-whenua, to which some reference has been made, it appears that one of Te Rau-paraha's sons, named Tupoa, was killed by Ngati Parere, a hapu of Mua-upoko. He was discovered lighting a fire (probably figurative language) at Kereru, so was waylaid and slain.

Knowing full well the storm that this action would bring about their ears, Mua-upoko prepared for battle. Invitations were sent out to Rangitane, Ngati Apa, Whanga-nui, and Nga Rauru, all of whom responded and sent their contingents; and all the old people, women, and children of the Mua-upoko were sent to the pa at Papai-tonga for safety.

The battle was fought at Otaki, at the rear of the present hotel, about half a mile from the mouth of the river; Ngati Toa, in combination with Ngati Awa, Ngati Rau-kawa, and Ngati Tama, being victorious. It is said that seven hundred men were killed in this fight, and after it was over Te Rau-paraha attacked Papai-tonga, where he killed a hundred more.

When Te Rau-paraha reached Waikanae he noticed a black cloud hanging over Kapiti, and, seeing in this sign an omen of further success, he again attacked the combined tribes at Horo-whenua, where he seems to have had but indifferent success, for he was driven to Kapiti by Mua-upoko, Ngati Apa, Rangi-tane, and Pehi Turoa, of Whanga-nui, with his three hundred men. Between Hao-whenua and the next *heke*, which we are able to describe, occurred the death of Taka-rangi at Kohuru-po. An account has appeared in the Jour. Polynesian Soc.; but, as we have additional notes, we will proceed to describe the events that led up to that battle and other affairs; so we will retrace our steps to the time of Kawana Hunia's birth.

Kawana Hunia, Hakeke's son, was born at Wai-tapu, a pa far up the Rangi-tikei River, and when he had grown out of childhood his father took him to Oroua, and placed him in the care of Hamiora, who arranged to look after him. He did this with the idea of creating a friendship, and to prevent his people of the Ngati Apa molesting Ngati Tauira and Macro, who had ceased to reside at Te Awa-mate and that neighbourhood, and had taken up their abode at Oroua, on account of the strained relationship which had for a long time existed between these hapus.

There was a song, a sort of lullaby, composed by two old men named Te Kowa-kura and Taku-te-rangi about the event, a translation of which we have endeavoured to render into rhyme :—

Kaati e tama te noho i to whare,
E puta ki waho ra ka haere taua,
Nga parae ka tokoto ki waho o Whaka-ari[*]
He uia mai koe kowai to ingoa,
Mau e ki atu, ko te Raro-o-te-rangi.
Kai ki mai te wareware,
Ka pau te whakanoa e te tini e te mano,
Naku ia nei na te Kahue-pepo,[†] te Roa-wai-rerewa[‡]
Kai whea o Tupuna hei whakawehi mai i mua ano Whaka-tau-potiki,[§]
Nana tokotoko te rangi runga nei,
Ka puta koe ki te whaiao ki te aomarama
Hikaka te haere ki runga Taikoria,[||]
Pukana o kaiu, ki roto Manawa-tu,
Kei o matua e tu mai ra i te one o te riri ka ngaro te tangata.
Aronui te haere ki roto o Horo-whenua,
Kia Powhiri mai koia e whaea,
E rau a te waka kia paua to rangi,
Te rau o te huia e noa te tinana tera to piki te hokio runga,
Nga manu hunahuna, kaore i kitea.
E te tini e te mano
Kia takaro koe nga takutai e takato i waho Wai-wiri,[¶]
I roto o Wai-kawa[**]
Ka eke koe ki runga o Puke-hou,[**]
Ka whakamau e tama ki waho Rau-kawa[††]
Ko nga moana ra e whakawhana noa ra o Tipuna i te kakau o te hoe
Ngaro rawa tu ki Hawaiki.

[TRANSLATION.]

Arise, my son, and leave thy home ;
O'er Whaka-ari's plains let 's roam.
If common folk inquire of thee
Regarding name and ancestry,
Then proudly thou shalt make reply,
" The Rib of Heaven above am I,
Sprung from line of warriors bold,
Descended from ancestor old,
Name known in mythology,
Whaka-tau-potiki."
He upraised to the sky
Up from earth the heaven high,
Thereby making all things bright,
For thee creating world of light.
Hasten, hasten, let us wend,
And Mount Taikoria ascend ;
There wrathful gaze on Manawa-tu
Where thy sires with courage true
Bravely fought ; and, sad to tell,
Upon its sands there many fell :
Ah ! for their fall to payment gain
Let not their spirits call in vain.
To Horo-whenua, far away,
Let us go without delay.

---

[*] Whaka-ari — The Sandon district.

[†] Kahui-pepe—The family of the Pepe (Pepe-mua, Pepe-roto, &c.), who were actors in the drama of Apa-kura in far Hawaiki.

[‡] Roa-wai-rerewa—All tall men, like the offspring of Wai-rerewa, also connected with Apa-kura.

[§] Whaka-tau-potiki—Apa-kura's son.

[||] Taikoria—A hill at Carnarvon, overlooking Manawa-tu.

[¶] Wai-wiri—The lake usually known as Pa-pai-tonga. Pa-pai-tonga is the island in the lake.

[**] Wai-kawa and Puke-hou—Both at Otaki.

[††] Rau-kawa—Cook Strait.

See Trans. N.Z. Inst., vol. xxv, p. 427.

There grand the greeting it will be
Of thy female ancestry
When their chief again they see.
All the tribe, with joy elate,
The war-canoe will decorate.
The hokio feather thou must wear
Because it is extremely rare;
The huia 's common everywhere.
On the joyful meeting-day
You must your dignity display
In fitting action, fitting speech,
On Wai-wiri's adjacent beach,
Near Wai-kawa. Ascend thou Puke-hou,
Beyond Rau-kawa gaze o'er depths below.
On it thy ancestors, in days gone by,
Their paddles grasped and made their *wakas* fly;
But they departed. to return no more.
Unto Hawaiki's dim and distant shore.

After making this arrangement, Te Hakeke did what he could to carry it out, so he abandoned his place up the Rangi-tikei River, and built two pas at Oroua. Then, determined on peace, he went to Manawa-tu, and sought an interview with his old enemies; and so successful was he that a chief of Rangi-tane composed a well-known song to the effect that these two great tribes, the Ngati Apa and Rangi-tane, had now met together for the first time in peace. The song commences,—

'Kaua te Hakeke e ra konei mai, titaha tonu atu ma te hori
Ki waho ra i, kai peka mai ki konei kai kamua
Hoki koe e taku hokowhitu e taku rua to rau e i.

[Translation.]

Let not Te Hakeke come near;
Let him keep away, lest he be destroyed
By my *hokowhitu* (140) and my two hundred. O!

(This was probably the conference of chiefs referred to in the *heke* lately narrated.)

After leaving his pa at Oroua, Te Hakeke went to Kai-kokopu, near the sea, while Maero, Rangi-waho, and Nga-potiki hapus took up their abode at Pukepuke. The chief did not stay long at Kai-kokopu, but returned to Oroua; but soon again he left that place, on hearing that Nepia Tara-toa and Nga Maunga, of Ngati Rau-kawa, were occupying Pae-roa, and underscrubbing bush there with a view to settlement, and that they were also using the Awa-mate eel-weirs. So he abandoned Oroua, and gathered together some of the scattered hapus of Ngati Apa, and again came to Parewa-nui, accompanied by the Kauae, Ngati Apa, and Ngati Tau-ira people, where they took up the clearings made by Ngati Rau-kawa, who had moved across the river to Piri-rau and Tara-toa as soon as they heard that Te Hakeke was on his way thither. As soon as Ngati Apa were once more settled at Parewa-nui, Ta-whito, the father of Paipai, of Whanga-nui (and grandfather of Hori Kerei, now living), came to Hakeke asking for aid. Hakeke responded, and sent messengers to Ngati Kauwhata and Ngati Upoko-iri, both of which tribes sent their men to aid in avenging Ta-whito's people, the Rangi Waho Tribe, some of whose men had been cut off by the Nga Raurus. So this tribe was duly attacked and defeated, but not downcast, for they came round inland seeking *utu*, and travelled to Poko-wharo, where they found it in the person of Wai-ina, the wife of Rawiri-te-mana-o-Tawhaki.

In the meantime Pehi Turoa came down to Whanga-ehu to cultivate Ngati Apa's land there, and Te Hakeke asked assistance from Ngati Raukawa to drive him off. They consented, and the combined war-party went to Whanga-ehu by way of a road called Pehipehi, which went along close below the Poko-wharo Block, and so they arrived at Mata-tero, where they set fire to the houses of Pehi Turoa, destroyed all his seed, and then retired to Kau-anga-roa, expecting an attack; but, as they were unmolested, they returned to Rangi-tikei. As Pehi Turoa had gone back to Whanga-nui after leaving his seed-kumaras at Whanga-ehu, he did not return immediately, although he had received word as to his loss by the hands of the Ngati Apa. But, while the other party killed Wai-ina, the Ngati Apa people naturally thought that Pehi Turoa had done this; so they built a pa, called Kohuru-po, a little below Mata-tero, on the Whanga-nui side of the Whanga-ehu River, and there they waited for the expected attack with a strong garrison of Ngati Apa, Nga-riki, and Tupa-taua, under the command of Tu-ranga-pito. They had not long to wait. A large party of Ngati Rongo-mai-tawhiri, Nga Pae-rangi, and other Whanga-nui tribes, under the leadership of Taka-rangi and Tauria, travelled to Whanga-ehu, where they commenced a night attack. They fought all night, and in the early morning Whanga-nui's great chief Taka-rangi was killed. When the Whanga-nui people saw their leader had fallen they lost heart and fled, though up to this time they had been getting the best of it. Other chiefs of the Ngati Apa taking part in the fight were Aperahama Tipae, Hakaraia, and Rangi-pouri. After the victory Tu-ranga-pito climbed on the palisading of the pa, and sang the following song:—

Kahei koutou i haere mai ki te riri
I haere mai koutou ki te patiti ahi
Hei whakahoki riri, ta turikutia!
Ngati Rongo-mai-tawhiri e
Whai roroa i to riri e,
Whaka rongo ma ra,
Tenei te hunga kiro kei a au anake
Hua noa i a wai, he mea purotu koe,
No maua nei hoki tahi hiki ra
Nana ra i waiwaha,
He waka pakaru kino ki te akau raia ra, i.

[TRANSLATION.]

You came not hither to battle—
You came to enjoy the fire;
But, being weary,
You could not stem the battle's tide.
You should not follow up warfare,
For you are only fit
To sit around a fire
And feel its glowing heat.
Hearken unto me
And look upon my face,
For I am grieved at this man's death
I thought within myself
He would remain with me
As my beloved friend;
He taught me all my ways;
But now
He is but as a proud canoe
Tossed ashore by restless waves.

This translation gives but a feeble idea of the grim satire of the original, which was yelled and shouted at the top of the voice as a defiant battle-cry.

TABLE 8.

Hihi-mua
|
Rangi-tua-waru = Hine-kehu
|
Teura
|
Kato-poua = Te Kiri
|
Taka-rangi (killed at Kohuru-po)
|
Rora-awhe-uru (1.) = Mete Kingi
|
Mete Kingi   Taka-rangi Mete Kingi (age about 65).

After this victory Te Hakeke expected that, with the death of such a prominent man, there would be a strong combination against Ngati Apa, so he assembled all the branches of the tribe at Paewa, and all the rest of the country was deserted. Whanga-nui expected from these preparations that there would be a great war-party from Ngati Rau-kawa, who were by this time firm friends with Ngati Apa, and were living at Poutu, just across the river from Paewa. So Hori Kingi Te Ana-ua sent his brother Te Mawai to Hakeke to make peace—or, rather, to prevent a war; for the influence of Europeans was now being felt, and the Natives saw how their constant internal troubles were thinning their ranks. So peace was made at Paewa, and the Whanga-nui messengers returned home.

After the victory at Kohuru-po the death of Ao-kehu occurred. Once more the war-cloud gathered, when Rangi-tane came to Whanga-ehu and Turakina to kill the people of those places, and when they thought they had killed all the people they went away. Tawai-whea, a great chief of Ngati Kahu-ngunu, was the chief man of that party.

Now, when Te Ao-kehu heard that all the people of Whanga-ehu and Turakina had been killed, he pursued Rangi-tane, and overtook and killed them all on the sea-beach. Koko-pirangi also met that war-party at O-takapo (a well-known station between Bull's and Turakina), and again defeated them. (Here an effort was made to impress upon the narrator the fact that it must have been the ghosts of that war-party that Koko-pirangi met, as they were *kua mate*; but he failed to see it.) These war-parties came straight to Turakina and Whanga-ehu from Here-taunga.

Then Rangi-haeata, or Mokau, as he was sometimes called, of Ngati Toa, Te Ratu, and others came down on the Rangi-waho and Maero people who were living at the Awa-mate Pa, and defeated them there, and then came on to Waipu. Here Te Ao-kehu, who was Hakeke's grand-uncle, fell in with them as he was travelling from Rangi-tikei to Whanga-nui. When the Wai-riki people heard the guns of the invaders they rushed to Rangi-tikei, leaving Te Ao-kehu and a few others to fight, and so by evening Te Ao-kehu and all his people had been killed.

When word was brought in that Te Ao-kehu had been killed, the whole of the hapus went to Oroua and to different places of the Rangi-tikei River, with the exception of one party who went up the Turakina to their pa Puke-ahua, where they lived with the Ngati Tupa-taua. Ngati Toa followed the fugitives, and some of the old men were caught at Oroua. Whare-peta and Hira were both caught there, as well as others whose names are forgotten.

After this a war-party from Wai-kato came down under Te Horita, of Ngati Wha-naunga,* but in the meantime the Ngati Apa who had scattered before the Ngati Toa guns had come back to their own places. They fought Wai-kato at the Te Ara Pa, where for a time Ngati Apa had some measure of success, but in the end they were worsted.

After Hao-whenua and Kohuru-po, came another *heke* from Taupo, the last of which we have any details. The journey was described by the same native that narrated the "Kariri-tahi" journey, and is as follows: "After we returned from Kapiti we remained a long time at Taupo, and then came down again after Hao-whenua. We came down by the Mokai Patea road, mustering five hundred strong. At Mokai Patea a few of the Ngati Tama met us, and came on with us to Kawa-tau. We travelled overland this time, and did not canoe down the river, but travelled the track by the river, calling at Te Pounga, Otara and Mako-hine, Te Pohue, and Te Ana. Near here we found the whole of the Ngati Apa living in two separate fighting-pas, put up in defence of Whanga-nui. We had heard of the death of Taka-rangi at Whanga-ehu, and found they had thrown these pas up in consequence of an expected attack. Their principal chiefs with them were Marumaru, Tahataha, Tu-ranga-pito, and Aperahama Tipae. All the Ngati Apa chiefs were there with the exception of Hakeke. Leaving Te Ana, we pushed on to the mouth of the Rangi-tikei. Here we found Ngati Mania-poto returning from Hao-whenua. Ngati Tu-whare-toa and Whanga-nui had been with them, but they parted at the mouth of the Rangi-tikei, the latter travelling along the coast on their way home, while Ngati Mania-poto returned by way of the Rangi-tikei River, with the intention of attacking Ngati Hau-iti and Ngati Hine-manu on their way, because the latter tribes had neglected the Maori custom of sending presents of birds and food to Te Heuheu when he had passed through them on a former occasion" [apparently as a kind of tribute to his supreme position]. "These people had in consequence fled into the bush, and Ngati Mania-poto searched the neighbourhood for them, but in vain. From the Rangi-tikei River we pushed on, passed the Manawa-tu, and reached Otaki. The main body did not remain there long, and the rest stayed for about a year and a half, when they also returned by way of Manawa-tu, struck the river at Te Ana, and so returned home. This journey was called 'Hou hou rongo ki Hao-whenua'—that is, 'The peacemaking of Hao-whenua,' and took place about five years before Te Kuiti-tanga." (Kuiti-tanga, 1839, took place the day before the arrival of the "Tory," and is described in Wakefield's "Adventures in New Zealand.")

"And now, after all this fighting and feasting, there came yet another army, few in number but mighty in power, armed not with guns, but books; and soon the last fight was fought, the last banquet finished, our captives were liberated and returned to their homes at Parewa-nui and Rangi-tikei, and we also sent those home whom we had captured." (There is a song existing that refers to the returning captives. Hura is mentioned in it, and he is connected with Pukepuke: "Katahi te huhure ka tiketike.") Parewa-nui became the assembling-place of all the people, and Te Hakeke was the first teacher appointed there. But with the desire for knowledge came also the desire for guns. So Ngati Apa went on a visit to their distant relatives the Kiki-rongo, to try to obtain these coveted weapons; and while there some of the Ngati Apa people plundered food from the Ngati Kahungunu, who resented it, and retaliated by firing on the Ngati Apa. Thereupon a fight ensued, but neither side gained ground, so peace was made. But troubles were not yet quite over on all sides. There was a skirmish at Kiwitea known as Oiroa, where a young chieftainess of this name was taken prisoner, two persons being killed on the Ngati Hau-iti side. Then Ngati Hine-manu and Ngati Upoko-iri came from Ka-iri-take, on the Oroua. As soon as Ngati Apa heard of this, they defied them and threatened them with death; but, through the mediation of many chiefs present at a meeting held to arrange the expedition, no fighting took place, and peace was made —this time a lasting peace. Only one other murder took place to mar the union that has since existed, and this was the killing of a chief named Te Ngangi; but this was not revenged, and the chieftainess Ruta was given as a pledge of peace to Kawana Hunia of Ngati Apa (Hakeke's son).

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* Te Horita-te-Taniwha, of Ngati Wha-naunga, came from Coromandel, which was his home.

And now the gospel of peace and goodwill to man was proclaimed, accepted, and carried out—yes, lived for many a year with far more interest and zeal than in many a so-called Christian country.

List of Hapus (Sub-Tribes) of the Ngati Apa Tribe between the Whanga-ehu and Rangi-tikei Rivers.

(Kindly supplied by A. McDonell, Esq., of Lower Rangitikei.)

1. Ngati Kauae.
2. Ngati Rangiwaho.
3. Ngati Tauira.
4. Ngati Apu.
5. Ngati Tai.
6. Ngati Tupua.
7. Nga Potiki.
8. Ngati Tupa-taua.
9. Tama-kuia.
10. Ngati Rakei.
11. Nga Riki.
12. Ngati Tika.
13. Ngati Ratua.
14. Ngati Tu-moe-tere.
15. Ngati Tamatea.
16. Kiri-wheke.
17. Ngati Kahu-wai-rua.
18. Ngati Tamaea.
19. Ngati Rangi-pokini.
20. Rangi-puhi.

Art. XII.—*The Waterloo of the Waikato, fought in 1830, and its Effects on the After-enacted Land Laws of that Part of the North Island.*

By W. Welch, F.R.G.S.

[*Read before the Manawatu Philosophical Society, 29th April,* 1909.]

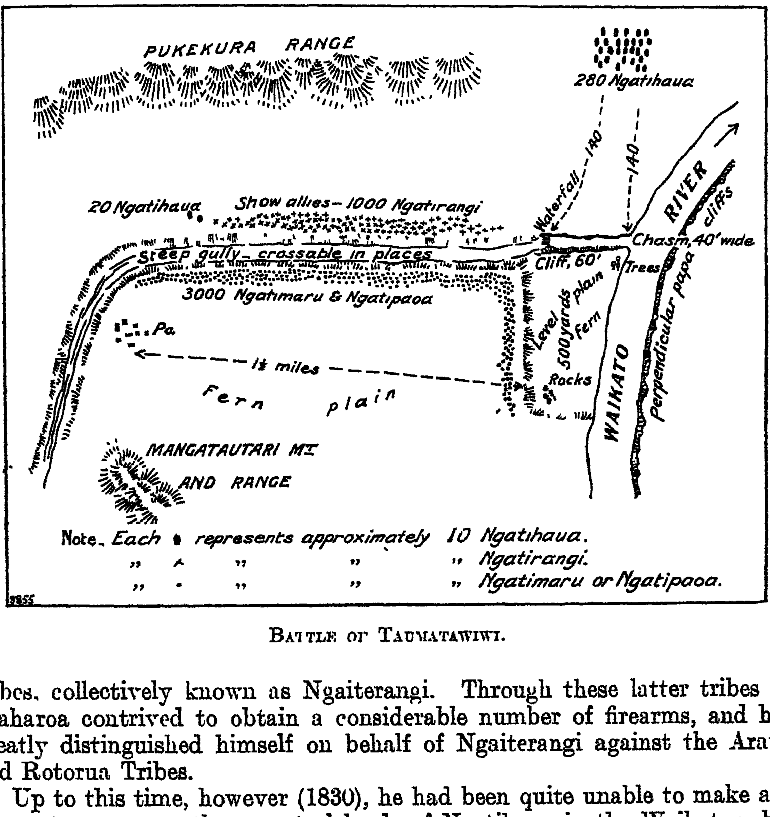
The Battle of Taumatawiwi, fought in 1830, may well be termed the Waterloo of the Waikato. A few words will explain the importance of the battle.

The Maori tribes north of Auckland, collectively known as Ngapuhi, were the first to obtain firearms in quantity. With the new weapon these tribes overran the North Island, slaughtering and capturing prisoners almost with impunity. Their incursions into the Waikato culminated in the storm and massacre of Matakitaki Pa in 1822.

Ngapuhi, however, formed no permanent settlements south of Auckland; they only depopulated the Waikato and Waipa districts.

The tribes collectively called Ngatimaru and Ngatipaoa, of the lower Thames and south coast of Hauraki Gulf, were also by this time (1822) becoming well supplied with firearms, and they invaded, with intention of permanent settlement, the almost wholly depopulated great triangle formed on the west and east by the Waipa and Waikato Rivers, and by the Maungatautari Mountain and Range in the south.

Between the years 1814 and 1822, Ngatihaua, under their politic and warrior chief Te Waharoa, driven from their proper homes on the Waikato, maintained by sheer talent and bravery their tribal individuality and independence in the inland country north of Rotorua and between the Waikato and Thames Rivers. They established friendly relations with the Tauranga tribes, collectively known as Ngaiterangi. Through these latter tribes Te Waharoa contrived to obtain a considerable number of firearms, and had greatly distinguished himself on behalf of Ngaiterangi against the Arawa and Rotorua Tribes.


PUKEKURA RANGE
280 Ngatihaua
140
140
Waterfall
RIVER
cliffs
20 Ngatihaua
Show allies – 1000 Ngatirangi
Chasm, 40' wide
Steep gully – crossable in places
Cliff, 60'
Trees
Perpendicular papa
3000 Ngatimaru & Ngatipaoa
Pa
1½ miles
Level 500 yards plain fern
Rocks
WAIKATO
Fern plain
MANGATAUTARI MT AND RANGE
Note. Each ♦ represents approximately 10 Ngatihaua.
" ▲ " " " Ngatirangi.
" • " " " Ngatimaru or Ngatipaoa.

BATTLE OF TAUMATAWIWI.

Up to this time, however (1830), he had been quite unable to make any attempt to recover the ancestral lands of Ngatihaua in the Waikato; but now (1830) he learned that the other remnants of Waikato tribes, having obtained firearms through the ports of Manukau, Kawhia, and Mokau, were forming plans to attack the Ngatimaru and Ngatipaoa, who had taken permanent possession of the triangular district above mentioned. Now, it would, according to Maori custom, be very derogatory to the prestige (*mana*) of Ngatihaua and their chief Te Waharoa if that district was reconquered by any one other than themselves, for, although, supposing the Waikato tribes were successful in expelling Ngatimaru and Ngatipaoa, Ngatihaua would certainly be allowed to return to their ancestral possessions, yet they would under such circumstances do so in a subordinate position.

Ngatihaua at this time mustered three hundred first-class warriors, ninety per cent. of whom had a firearm of some kind, and they had been disciplined by Te Waharoa, who for the previous eight years had taught every man of them to look forward to the time when they could burst into the Waikato, and by sheer valour recover their ancestral homes from the numerous enemy in possession.

News now came that the Waikato tribes had got together eight hundred well-armed men in the Hunua and Manukau Ranges. These now, under several chiefs, proposed to proceed up the Waikato and Waipa Rivers, while other parties were preparing to join them from the Pirongia Range on the west and Mokau on the south. It was time, therefore, for Ngatihaua to act, or leave to others the recovery of the land.

In this emergency Te Waharoa appealed to his friends (Ngaiterangi, of Tauranga) to lend him a thousand men, not to be exposed to imminent risk, but merely to make a show of force. Ngaiterangi consented. Te Waharoa got the thousand show allies, and the sketch on the preceding page will, I hope, illustrate the great battle that ensued while the Waikato war-parties were still several days distant.

The address of Te Waharoa to his people before leaving the Thames hills was short, and altogether to the point. "Our women and children," he said, "go with us, for we go to stay. If we cannot conquer, we can die. And our women and children shall be with us in either case. Any of you who have had 'omens' can remain here and join Ngaiterangi. At dawn of day we march. The women and children will follow. Enough! You are each as good a man as I, and it is my fixed intention to conquer before the Waikato tribes come up." There were no bad omens, and not a soul of Ngatihaua remained behind. In the afternoon of the following day they junctioned with their Ngaiterangi allies, and together they crossed the Waikato River a little above where the Town of Cambridge now stands.

The Ngatimaru and Ngatipaoa were formed along the brow of the gully and terrace, their left resting on their strong pa, their right on the perpendicular cliff of the Waikato River. Their whole line formed nearly a right angle, but they neglected to occupy the mass of loose rocks in the angle formed by the river-cliff and the steep terrace. These rocks, or mass of separate boulders, lay a few yards from the foot of the terrace. Te Waharoa noticed this, and these rocks became a distinct feature in his dispositions. He first of all disposed his thousand Ngaiterangi allies along the gully, with orders merely to keep up as hot a fire as they could across the gully, but he neither asked nor professed to expect from them any actual charge or hand-to-hand conflict. He, however, placed twenty picked men of his own Ngatihaua on the extreme right of his allies, with orders, on a given signal, to charge across the gully regardless of the number opposed to them, and to incite by their example as many as possible of their allies to follow. He then divided the remaining Ngatihaua into two bodies of 140 men each. The left detachment had no leader, as it was extremely uncertain which of them would reach their destined point of attack; but every man of this 140 knew the orders—viz., that they were to creep through the fern to the edge of the chasm, and lower themselves by ropes to the bottom. Five women were detailed to creep after the column and let the ropes go when all the men had got to the bottom. The men were then, by means of notches cut in the papa cliff, to get at least one man and a rope to the top: then by means of the ropes they all could get up more speedily, taking cover in the little clump of trees until all were on the upper level; then at a given signal all were to run at best speed, and in the loosest possible order, to the rocks at the end of the level. There for a moment they were to halt and get together, and then charge with all their might on to the extreme end of the enemy's line.

While this operation was in progress, the right-hand 140 Ngatihaua advanced close to the waterfall, and kept up a hot fire on the angle formed by the terrace and the gully. Te Waharoa himself kept a little farther back, on the slope of Pukekura Hill, until he saw the attack from the rocks on the enemy's right taking effect. Then, shouting his battle-cry, he made the signal to his twenty men on the extreme right of his allies, and charged with the whole weight of his 140 men on the angle of the enemy's line, just over the waterfall. At the same moment the twenty Ngatihaua on his extreme right charged across the gully, and in the enthusiasm of the moment and the natural love of a Maori for battle many of the Ngaiterangi allies followed them.

About forty of the left column of Ngatihaua had fallen in the 500-yards race from the little clump of trees to the rocks, but the remaining hundred now came storming furiously and irresistibly along the enemy's long line. The determined charge of Te Waharoa, with his 140 men, on to the centre of the enemy kept them pretty well employed until the cry arose among the enemy that they were being cut off from their pa and their women by the desperate charge of the Ngatihaua twenty on the extreme right (left) of the enemy. This charge, too, was momentarily increasing in weight by parties of Ngaiterangi crossing the gully.

The left column of Ngatihaua from the rocks actually rolled up the enemy's line until the two parties of Ngatihaua met at the angle. Then the united columns, still holding the flank of the enemy, continued the charge, until the cry arose among the enemy that they were being cut off from their pa; then the fight became a rout.

The ten survivors of the right-flank Ngatihaua detachment stood as rocks, back to back, amid the deluge of the retreating enemy, until the last of these got within the pa. Ngatihaua and allies then immediately retired out of "Brown Bess" range—for there were no 1,000-yards rifles in those days.

Ngatihaua lost altogether seventy men killed and ninety wounded. The enemy lost 440 killed and about as many wounded. Those slightly wounded escaped to the pa. The enemy, however, had still considerably over two thousand men, and Te Waharoa could not implicitly depend on his allies. The Ngatihaua dead were therefore carefully collected, and the bodies forthwith cremated, in case they might fall into the hands of the enemy. When the writer last saw the place, in 1880, a small flagstaff still marked the spot where the bodies were burned.

During the night after the battle negotiations were opened—at first between Te Waharoa's Ngaiterangi allies and the enemy in the pa. Next day the matter was referred to Te Waharoa, and that wise and politic chief readily agreed to cease hostilities, provided the Ngatimaru and Ngatipaoa retired at once, "bag and baggage," from Waikato, and returned to their own proper district. This they accordingly did, escorted by Te Waharoa's Ngaiterangi allies and fifty Ngatihaua.

Te Waharoa, with the remaining 180 Ngatihaua (half of them wounded), and the women and children, took possession of the enemy's pa, and remained there to receive the advancing Waikato parties from south-west and south.

The reason I have termed this battle the Waterloo of the Waikato is that in our time the Native Land Court has held that all that region was completely conquered and occupied by Ngatimaru and Ngatipaoa, and reconquered by Te Waharoa and Ngatihaua; consequently, all land titles in that region date from the Battle of Taumatawiwi.

[I am much indebted to Mr. A. McDonald, of Palmerston North, for his valuable assistance in getting the facts required for this paper.]

ART. XIII.—*The Vegetation of the Kermadec Islands.*

BY REGINALD B. OLIVER.

[*Read before the Philosophical Institute of Canterbury, 6th October,* 1909.]

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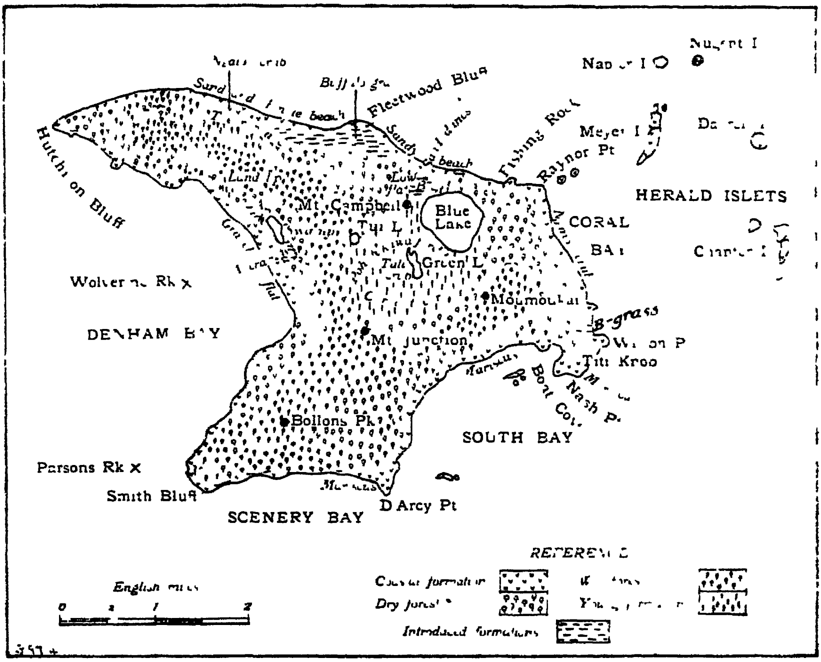
I. INTRODUCTION.

IN an area such as the south-western Pacific, where any one island does not include parts of two biological regions, one might imagine the limits of each region could be easily defined. Yet such is not the case. True, it is generally agreed that the several islands to the south and east of New Zealand—

Auckland, Campbell, Macquarie, Antipodes, Bounty, Chathams—unquestionably belong to the New Zealand region, as not only do their natural productions closely resemble those of New Zealand, but the geological structure of some suggests the probability of a former land connection with that country. To the north of New Zealand, however, there are three islands or groups of islands possessing floras and faunas as to whose relationships botanists and zoologists are not agreed. I refer to Lord Howe Island, Norfolk Island, and the Kermadecs. Being all of volcanic origin, they bear no geological evidence of having ever been directly connected with any land-mass. Sunday Island is perhaps an exception, as the pumice tuffs on the north coast include some fragments of hornblende-granite.



BOTANICAL MAP OF SUNDAY ISLAND.

Lord Howe Island is included under New South Wales in Mr. Bentham's "Flora Australiensis," and in Baron von Mueller's "Census of Australian Plants" Norfolk Island as well is included in the Australian region. Professor R. Tate has pointed out (18; p. 205) that the floras of Lord Howe and Norfolk Islands are allied to that of New Zealand; but these islands are not included in the New Zealand area by Mr. Cheeseman in his "Manual of the New Zealand Flora," though he enumerates the plants of the Kermadecs.

There is as little agreement among zoologists as among botanists respecting the region to which these islands belong. Australian zoologists claim them apparently because they are most easily worked from Sydney, but Dr. A. R. Wallace has shown (19; p. 453) that their faunas are really allied to that of New Zealand; and Messrs. Parker and Haswell (15; p. 596) follow Wallace in including them in the New Zealand region. Mr. W. L. Sclater draws the line between Norfolk and Lord Howe Islands.

If the contour of the ocean-floor be taken into account, the three above-mentioned islands fall without the boundaries of the Australian region, for Lord Howe Island is separated from the continent of Australia by an ocean over 4,000 m. deep, but is connected with New Zealand by a submarine ridge less than 1,800 m. below the surface; whilst Norfolk Island and the Kermadecs are much nearer to New Zealand than to Australia, and lie on submarine ridges stretching from New Zealand to Polynesia, though deeper than that reaching to Lord Howe Island.

As regards the claim of these islands to be included in the Polynesian region, although some Polynesian species and genera of plants reach their southern limit in one or more of them, the proportion is not large enough to warrant the inclusion of the islands in that biological region.

The New Zealand biological region may be defined as including all those islands in the south-west Pacific Ocean lying between the parallels of 25° and 60° S. lat. and the meridians of 155° E. and 175° W. long. From a consideration of the distribution of the plants in New Zealand, Dr. Cockayne has divided the two main islands and Stewart Island into provinces, each characterized by certain floristic and ecological features (5; p. 313). North of latitude 38° is the northern, south of latitude 42° the southern, while the intermediate parts he calls the central botanical province. The islands to the south of New Zealand form his subantarctic islands botanical province, while the Chathams and Kermadecs each form a separate province. In the section of this paper dealing with geographical distribution I have endeavoured to show that Lord Howe Island, Norfolk Island, and the Kermadecs together form a natural division, for which I propose the name "subtropical islands province."

Situated as the Kermadecs are, midway between New Zealand and the Tonga Group on the southern boundary of the Polynesian region, their fauna and flora are of interest alike to New Zealand biologists and students of geographical distribution. The geological structure of the islands, too, may indicate the route and date certain Polynesian species of plants entered New Zealand. The present islands do not seem to have acted as stepping-stones for the passage of many plants between Tonga and New Zealand, or *vice versa*. *Hymenophyllum demissum* and *Ascarina lucida* may be examples of migrants in the first direction, while *Melicytus ramiflorus* has reached Eua either from Norfolk or Sunday Island. The Kermadecs are the most easterly of the three groups of islands which mark the northern limit of the New Zealand region, and, as they lie far from any land whence they could derive their stock of plants and animals, a knowledge of their flora and fauna will be interesting as showing which organisms are capable of crossing wide stretches of ocean. As to the means of making the journey, some remarks are made under the heading "Geographical Distribution."

It was my intention to confine myself to a description of the plant covering of the Kermadec Group, and an enumeration of the species found therein: but the affinity of the flora to that of Lord Howe and Norfolk Islands appeared to me striking, and not without significance, hence I thought it advisable to preface my account with a statement of what I believe to be the true position of the Kermadec Islands in the New Zealand biological region, which expression in this paper will include Lord Howe

Island and Norfolk Island. The floras of these two islands will only be mentioned in so far as they are related to that of the Kermadecs.

Before closing this introduction I wish to express my sincere thanks to those who in one way or another made it possible for this paper to be written: firstly, to those who helped the expedition before leaving New Zealand, and especially to Dr. Hilgendorf, M.A. (then President of the Canterbury Philosophical Institute), Dr. Cockayne, Professor C. Chilton, M.A., D.Sc., and Mr. E. R. Waite, F.L.S.; to the Councils of the Otago Institute and Canterbury Philosophical Institute for grants of money to help defray expenses; to the Marine Department for the loan of meteorological instruments; to Lieutenant Sir Ernest Shackleton for the gift of a boat; and, finally, to those who so readily gave assistance while I was writing the paper—to Mr. T. F. Cheeseman, F.L.S., who looked over one of the collections of plants made by me in the Kermadecs and named the specimens; to Mr. J. H. Maiden, of Sydney, who kindly compared some of my specimens with plants from Norfolk Island; to Dr. Cockayne for many valuable suggestions; and to Mr. R. Speight, M.A., B.Sc., who gave advice on geological matters.

II. HISTORY OF BOTANICAL INVESTIGATION.

In 1854 Captain H. M. Denham, in H.M.S. "Herald," made a survey of Sunday Island and the neighbouring seas (17; p. 14). He arrived on the 2nd and was occupied till the 24th July, during which time he frequently had to move his vessel on account of the rough weather experienced. Messrs. J. Milne and W. MacGillivray, naturalists on board the "Herald," made a small collection of plants on Sunday Island. This was forwarded by Captain Denham to Sir W. Hooker, and was described by Sir Joseph Hooker in the Journal of the Linnean Society for 1857 (10; p. 125).

The number of species collected was 41, of which 21 were pteridophytes and 20 spermophytes. Four species were described as new—*Coprosma petiolata*, *C. acutifolia*, *Scævola gracilis*, and *Ascarina lanceolata*.

In the "Handbook of the New Zealand Flora" (1864–66) 40 species of vascular plants are mentioned as occurring in the Kermadecs. Of those recorded in the Journal of the Linnean Society, four are omitted, doubtless unintentionally, while three species are added—namely, *Nephrodium molle*, *Coriaria thymifolia*, and *Acæna Sanguisorbæ*. These must have crept in by accident, for no one is known to have collected plants on Sunday Island between 1854 and 1864. Two of them do not occur in the Kermadecs; the third, however, *Dryopteris parasitica* (= *N. molle*), is a common plant on Sunday Island.

In 1887 the New Zealand Government despatched the colonial steamer "Stella" to the Kermadec Islands for the purpose of formally annexing the group to the colony. Captain Fairchild left Russell on the 12th August, and, after a stormy passage to and from the islands, anchored under Cape Maria van Diemen on the 27th August. Landings were effected on Sunday, Macauley, and Curtis Islands. Mr. T. F. Cheeseman, Curator of the Auckland Museum, accompanied the expedition, and, being interested chiefly in botany, made a large collection of plants on Sunday Island, the result of his investigations being published in vol. xx of the "Transactions of the New Zealand Institute" (1; p. 151). In the catalogue he gives of phanerogamic plants and ferns inhabiting the Kermadecs, 115 are enumerated.

but in seven cases the species could not be determined. Mr. Cheeseman's conclusions are.—(1) The Kermadec Islands have received their plants from two sources: there have been two opposite streams of colonisation—one, much the larger and more important, from New Zealand; the other, much less conspicuous, from the Polynesian islands. (2.) The nature and composition of the flora, the relationship to those of New Zealand and Polynesia, and the peculiarities generally, are best explained on the supposition that the islands have been slowly stocked with their plants by chance migrations across the ocean.

Since the publication of the above, two other papers dealing with the flora of the Kermadecs have appeared in the "Transactions of the New Zealand Institute" (2 and 7), in which four new species are described. Only one, however, *Poa polyphylla*, is an addition to the flora, the others being included in Mr. Cheeseman's list.

Mr. Cheeseman in his "Manual of the New Zealand Flora" includes the names of 104 species of plants as occurring in the Kermadec Islands. From the list given in vol. xx of the Transactions he omits one as being introduced (*Polypogon monspeliensis*), and seven others, the omission of three of which (*Mariscus ustulatus*, *Paspalum scrobiculatum*, *Dichelachne sciurea*) is probably due to an oversight. *Diplazium japonicum*, and three species (including *Poa polyphylla*) collected by Miss Shakespear, are added. This brings the number of species recorded to 107, if the three above omissions be included.

Early in 1907 Mr. W. L. Wallace, of Timaru, and myself made arrangements to visit and stay for a year on Sunday Island for the purpose of studying plant and animal life. Subsequently Messrs. T. Iredale, C. E. Warden, and S. R. Oliver joined the expedition. We left Auckland in the New Zealand Government steamer "Hinemoa" on the 28th December, 1907, and landed our provisions, instruments, &c., in Denham Bay on the 31st December. From a camp in Denham Bay and another near Fleetwood Bluff as bases the whole island was explored, while a motor-launch was used to visit the outlying rocks. The "Hinemoa" called again on the 7th November, 1908, but owing to bad weather we were not able to ship our goods until the 11th. We landed on Macauley Island, Curtis Island, and French Rock on the voyage back, and reached Auckland on the 16th November.

The Kermadec Islands were chosen as the object of our investigation on account of their being in certain respects a little-known portion of the New Zealand biological region. Our collections included specimens of rocks, plants, and animals; while meteorological observations were taken daily for a period of nine months. Besides collecting specimens, I paid much attention to the plant formations existing on the islands. Following are some of the results of my investigations.

The number of species of plants added to the flora is fourteen:—

Trichomanes humile,
Hymenophyllum flabellatum,
Cyathea kermadecensis, n. sp.,
Nephrolepis cordifolia,
Histiopteris incisa,
Lycopodium volubile,
Danthonia pilosa,
Dichelachne crinita,
Heleocharis acuta,
Kyllinga brevifolia,
Carex lucida,
Juncus effusus,
J. pauciflorus,
Erechthites prenanthoides.

Two species hitherto incorrectly indentified, owing to the imperfect nature of the specimens, I am now able to name,—

Dryopteris glabella (A. Cunn), C. Chr. = *Nephrodium decompositum*, Hook. f., Jour. Linn. Soc. (Bot.), vol. i, p. 129 (not of R. Br.);
Veronica breviracemosa, R. B. Oliver = *V. salicifolia*, Cheeseman, Trans. N.Z. Inst., vol. xx, p. 171 (not of Vahl).

Five species are transferred to the list of introduced plants.—

Cordyline terminalis,
Geranium molle,
Aleurites moluccana,
Ageratum conyzoides,
Sonchus oleraceus;

and three do not occur in the islands.—

Agropyrum scabrum,
Acæna Sanguisorbæ.
Coprosma Baueri.

Asplenium Shuttleworthianum is here restored to specific rank; so that the total now stands at 114 species.

III. GEOLOGY.

The Kermadec Islands, four in number, lie in a line extending from Sunday Island, in S. lat. 29° 15′, W. long. 177° 59′, about S. 22° W. to French Rock, in S. lat. 31° 24′, W. long. 178° 51′. They are situated on a submerged plateau, part of the submarine ridge connecting New Zealand with Tonga. This plateau, which is surrounded on all sides by water more than 2,700 m. in depth, is now probably rising, as the last movement of which there is any evidence was an upheaval of Sunday Island to the extent of about 60 m.

Sunday Island, the largest of the group, is distant about 950 km. from Tongatabu, and 1,000 km. from the North or East Capes of New Zealand. Its greatest length is 10·3 km., and its area 29·25 sq. km.; Moumoukai, the highest point, is 524 m. above sea-level.

Sunday Island is composed chiefly of pumiceous and other tuffs. There are a few lava-streams, but these have little effect upon the vegetation other than forming the substratum for certain of the coastal and inland rock formations. The tuffs, being of a more or less loose nature, suffer severely from the action of sea and atmosphere. The whole island is of a mountainous character, and the surface has been formed by subaerial denudation into a series of narrow spurs separating deep ravines. Towards the coast these spurs usually terminate abruptly in cliffs with a sheer drop to the sea of from 200 m. to 300 m. The crater occupies a large portion of the island. The rim is low and narrow on the north, the lowest point being only 55 m. above sea-level; elsewhere it is high, averaging over 300 m. From it there branch off three main ridges: one runs north-west from Expedition Hill to Hutchison Bluff, another south-west from Mount Junction to Smith Bluff, and the third south-east from Moumoukai to the east coast. Level ground occurs in Denham Bay, in the crater, and on Low Flat and the adjoining terraces. There is a swamp in Denham Bay, and three lakes in the crater.

Except for a gravelly beach in Denham Bay, and a sandy one on the north side of the island, the coast is rocky—sometimes boulder beaches; more often cliff-*débris*, consisting of large and small angular blocks of lava or tuff. Hence the variety of stations afforded for salt-loving plants is limited.

Through the kindness of Captain Bollons I was able to land on all the islands visited on the voyage from Sunday Island to New Zealand. I am therefore able to give some account of the geology and botany of the three islands of the Kermadec Group lying to the south-south-west of Sunday Island.

Macauley Island, distant 109 km. from Sunday, is 2 km. long and 3 sq. km. in extent. The highest point, 237 m. above sea-level, is near the western end, and from here the land slopes away gradually to the eastward, terminating everywhere in cliffs which can be scaled at one place only —the Lava Cascade. The island is composed of beds of pumice overlying lava, and covered with some vesicular scoria and ash, which forms the soil.

Curtis Islands, 35 km. from Macauley, consist of two rocky islets—detached portions of a crater in a state of thermal activity. The total area is about 0·6 sq. km., and the highest point 100 m. above sea-level. The crater-floor contains much hot mud and sulphur, while numerous holes filled with boiling water are dotted about. Apparently the islands are composed of a kind of tuff. In the short time I was there I saw no lava.

French Rock is distant 83 km. from Curtis Islands. It is composed entirely of lava rocks, and is about 250 m. in length and 50 m. in height.

The geological evidence of the age of the islands is conflicting. As pointed out by Mr. Speight,* the occurrence of fragments of hornblende-granite indicates the presence of a continental area. On the other hand, any land connection with either Tonga or New Zealand must have been very remote, as deep water now entirely surrounds the Kermadec Group. The structure of Sunday Island is that of a tuff cone built up on a base which at the time of the first deposits was submerged. The oldest visible beds, which fortunately contain fossils, are of submarine origin, and do not, I think, date back further than the Pliocene age. The character of the flora, and the small proportion of endemic species of plants, are further evidence of the recent appearance of the present islands above the surface of the sea. That the Kermadec plateau once formed part of a continent extending in a north-and-south direction is probable; but the fragmentary nature of the productions of the group demands that this land should be submerged before the present islands came into existence (see 1; p. 161).

IV. CLIMATE.

The Kermadec Islands are situated near the southern edge of a belt of calms and variable winds lying between the south-east trades and the region of westerly winds. This belt moves slightly northward during the southern winter, so that the weather experienced on Sunday Island in 1908 included many westerly gales during the winter months, but for the remainder of the year was changeable, with some settled weather in March and April. Generally speaking, the climate is mild and equable, with many rainy days, considerable precipitation, much wind, especially in the winter months, and a constantly humid atmosphere.

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* "Petrological Notes on Rocks from the Kermadec Islands, and some Geological Evidence of a Former Subtropical Pacific Continent." (See p. 241 of this volume.)

Neither a drought nor a hurricane was experienced during my stay on Sunday Island, though both are known to occur there. On one occasion, according to Mrs. T. Bell, who has lived on Sunday Island for the past thirty years, no rain fell for a period of five months; while hurricanes have visited the island about nine times since 1878. The effect of a hurricane is to be seen in one place in Denham Bay, where every tree in its path is blown down. In the forest generally a leaning tree here and there, and the prostrate habit of the large trees of *Metrosideros villosa* on the ridges, are the only signs of the effect of hurricanes. The trees affected are usually leaning in a northerly direction—that is, away from the quarter (south-east) whence the hurricanes are said invariably to blow.

The temperature during the nine months, February to October, 1908, varied between the extreme limits of 8·7° C. on the 4th August and 29·4° C. on the 1st February, though days hotter than this occurred in January before regular observations were taken. A note in my diary shows a maximum reading of 31·7° C. for the 29th January.

The rainfall is distributed fairly evenly throughout the year, and for the nine months totalled 1,716 mm. In cloudy and rainy weather a mist continually hangs about the hilltops, hence the upper portion of the island receives a considerable amount of moisture more than the lower-lying ground. As a consequence, the upper forest of Sunday Island is quite different from the lower, though the one imperceptibly passes over to the other at an altitude of 200 m. to 300 m.

Calm days are rare, and the wind often blows with great violence. On the 2nd April no horizontal movement of the air was recorded by the anemometer; on the 9th March the instrument registered 1,087 km.

On 76 out of 274 days covered by the nine months during which readings were taken the air was saturated. The driest day was the 3rd February, when the degree of relative humidity was 51.

The amount of cloudiness (observations taken at 9 a.m.) averaged 0·6 of the visible sky.

I give two tables showing the weather-conditions at Denham Bay, Sunday Island, for 1908. The observations were taken by Mr. C. E. Warden, but I am entirely responsible for the figures as they appear here corrected and tabulated. Table I shows the weather month by month, while Table II shows the duration of each kind of weather.

TABLE I.

Month, 1908.	Temperature, C°.			Rainfall.		Wind.	Relative Humidity.
	Min.	Max.	Mean.	Mm.	Days.	Km. per Day.	Per Cent.
February ..	20·3	25·9	23·1	198	16	364	81
March	19·0	25·8	22·4	175	14	354	90
April	16·8	24·2	20·5	287	16	209	95
May	15·6	21·4	18·5	172	21	200	96
June	15·0	20·1	17·6	151	21	275	93
July	13·3	19·4	16·3	170	27	467	97
August	13·3	18·2	15·7	237	19	401	91
September ..	12·6	19·2	15·9	100	18	256	84
October	14·9	20·9	17·9	226	24	425	89
Means and totals	15·7	21·7	18·7	1,716	176	328	91

TABLE II

Direction of Wind.	Temperature, C°.			Rainfall.		Wind.		Relative Humidity.
	Min.	Max.	Mean.	Mm.	Days.	Km. per Day.	Days.	Per Cent
S.E ..	14·4	20·6	17·5	27	14	195	30	87
E. ..	17·2	23·7	20·4	154	29	249	60	88
N.E. ..	16·3	21·6	18·9	597	20	372	26	94
N. ..	15·3	20·7	18·0	304	15	314	19	93
N.W. ..	16·0	21·3	18·6	411	27	404	30	95
W. ..	15·0	22·1	18·5	100	43	346	63	93
S.W. ..	14·7	21·0	17·8	73	17	448	29	88
S. ..	15·0	20·2	17·6	50	11	356	17	88

V. INTRODUCED ANIMALS AND PLANTS.

The effect of animals and plants introduced intentionally and accidentally through the agency of man is most marked on the vegetation of Sunday and Macauley Islands. *It amounts to an alteration of the forest formation on Sunday Island; and the occupation of ground cleared of forest or scrub, by meadow formations on both Sunday and Macauley Islands.* During the early part of last century Sunday Island was the headquarters of an extensive whaling industry carried on in the south-western Pacific. In order to afford means of subsistence for possible castaways the whalers liberated goats on Sunday and Macauley Islands, and, to provide the goats with pasture on Macauley Island, burnt the scrub so that grass might grow. The goats increased rapidly in their new home, and did not suffer from the lack of water on the islands, as these animals are satisfied with the moisture taken with the herbage. On Macauley Island they effectually prevented the regrowth of scrub, so that now *in all places accessible to them no more vegetation is to be found than a close-cropped beard-grass* (Polypogon monspeliensis) *meadow.*

On Sunday Island, as their numbers increased the goats spread to all parts, and, being expert cliff-climbers, little vegetation was beyond their reach. They wander about through the forest in herds of twenty or more, and eat a wonderful variety of vegetable substances—bark and leaves of trees, seedlings, and ferns—thus thinning the undergrowth considerably.

Certain plants once common have been almost exterminated by them, and are now found only on cliffs and other inaccessible places. Conspicuous examples are *Homolanthus polyandrus, Veronica breviracemosa, Asplenium lucidum,* and *A. Shuttleworthianum.*

The seedlings of other species are seldom allowed to grow up, and hence only such plants as begin their existence on *Cyathea* trunks, and, growing downwards and often strangling their host, take root in the ground, are able to reach maturity. This commonly happens with *Nothopanax arboreum,* which promises to become very rare or even extinct on Sunday Island; and often with *Metrosideros villosa.*

Young plants of *Cyathea kermadecensis* are greedily eaten, and, though mature plants of this magnificent fern are plentiful, young ones are extremely rare.

With *Rhopalostylis Baueri* a fair number of the seedlings grow up, as goats merely browse on the young palms, which are everywhere abundant.

The bark is stripped from the trunks of *Pisonia Brunoniana* and *Nothopanax arboreum* as far as goats can reach. This operation, however, kills

Homolanthus polyandrus, which plant Mr. Cheeseman in 1887 (1; p. 172) recorded as "not uncommon." The species is now almost extinct.

In Denham Bay sheep eat down *Scævola gracilis*, and in its place *Stellaria media* and *Cerastium viscosum* have become abundant.

The invasion of a number of European and other plants has not in itself much altered the physiognomy of the plant formations, but *where ground has been disturbed introduced plants are quicker than indigenous species in taking possession*. Introduced species do not readily spread far into the forest except in such places where the larger plants have deliberately been cleared away, and here three new and distinct formations have been created. These are the meadows described below.

Ageratum conyzoides was introduced thirty years ago, and is now abundant in several parts of the island. Possibly goats have assisted in spreading this species, which is the only introduced plant taking a prominent part in several of the plant associations.

VI. THE PLANT FORMATIONS.

All the plant formations on Sunday and Macauley Islands are more or less modified through the depredations of introduced goats, which have not only directly expunged certain plants from the forest, but in so doing have made openings which have been partly filled by introduced species. Hence in places it is difficult to imagine what the original forest was like, especially as it is known that a handsome tree, *Homolanthus polyandrus*, now absent, was once abundant in many places. The undergrowth perhaps suffers most from the introduction of goats, which search out particular plants whose elimination changes its appearance; also, by the extermination of *Homolanthus polyandrus*, and the suppression of young plants of *Pisonia Brunoniana*, *Nothopanax arboreum*, and *Cyathea kermadecensis*, the physiognomy of the forest may be entirely altered.

In the Kermadec Islands climatic conditions favour the growth of forest: all other plant formations except meadow occurring there may be classed as edaphic. The meadow formations owe their existence to the interference of man, and are gradually being superseded by forest; the swamp in Denham Bay, also, appears to be drying up, and forest taking its place.

The plant formations, then, naturally fall into two groups—the climatic, the character of whose vegetation is governed by atmospheric precipitations, and the edaphic, whose vegetation is chiefly determined by the nature of the soil (16; p. 161). In this paper the plant formations of the Kermadecs are arranged according to their possible evolution, and are divided for purposes of description into five groups—(1) coastal, (2) inland edaphic, (3) forest, (4) young, (5) introduced. The climatic formations are included in the third group, while groups (1) and (2) are edaphic. The last two groups may be termed unstable formations.

Supposing we go back to early Pliocene times, when the Kermadecs were just appearing above the sea-surface, and try to imagine what the conditions would be. The first plants to gain a footing on the new land would be those able to stand wetting with sea-water, such as are now found among coastal rocks.* Thus the coastal formations would be the first to appear on small oceanic islands, and the order would be the vegetation of rocks, scrub, sand dunes. Examples of islands in this stage are French Rock and Curtis Island. Next, as the land increased in area there would be more ground beyond the reach of salt spray, and stations for land-plants would appear, the order being rocks, perhaps swamp and lake, and finally forest. The destruction of areas of forest by volcanic eruptions or landslips would create new ground where the process of colonising would begin anew, but under entirely different conditions, as the devastated area would be surrounded by forest, which would only be hindered from spreading by the barren nature of the soil; and a new factor so far as the formations here described are concerned is the presence of species of introduced plants and animals. On Sunday Island we are able to watch this actually going on, there being two such areas in process of being re-forested. One was caused by a large landslip about four years ago, the other by a volcanic outburst in 1872.

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* On Krakatoa the first plants to appear after the destruction of the vegetation in 1883 were chiefly ferns (Treub., quoted by Schimper, 16; p. 185), but the island which remained after the eruption was of some considerable area.

The last period in the history of the plant formations began with the advent of man. Hardy cosmopolitan plants were introduced, the original formations cleared, and the ground immediately occupied by the new-comers.

1. *Coastal Formations.*

Only such formations as can be called "coastal" in the narrowest sense of the term are included in this section. Coastal conditions (see 5; p. 316) depend upon the distance sea-spray may be carried inland regularly and in large quantities by air-currents, which along the shore almost invariably blow towards the land. For instance, in Denham Bay, which is on the west side of Sunday Island, easterly winds coming over the top of the high cliffs have the effect of causing an inrush of air along the beach to compensate for the withdrawal of air from near the cliff-face. Other factors making coastal conditions are salt in the soil, and the little water-holding capacity of the substratum, which in the Kermadecs is rocks, sand, or pumice.

(*a.*) *Rocks.*—Under this heading I will include the vegetation of rocky shores and shingle beaches. All the coast-lines of the Kermadec Islands, with the exception of Denham Bay and Low Flat beaches on Sunday Island, are rocky, and differ but little in their vegetation. As in the winter months gales are frequent, the vegetation is often drenched with salt water, while during hurricanes the waves break over a considerable tract of land all round the coasts. The smallest quantity of soil on a ledge or in a crevice seems sufficient to support vegetation, which must rely for its existence chiefly on the abundant rainfall, which, besides supplying moisture, washes down earth from the cliffs above. Plants of *Asplenium obtusatum* were noticed on the roofs of caves, in which position they depend entirely on the percolation of rain-water carrying sediment through rock-crevices.

The principal plants composing the coastal rock vegetation are *Mesembryanthemum australe*, *Asplenium obtusatum*, *Poa polyphylla*, *Coprosma petiolata*, *Samolus repens stricta*, *Lobelia anceps*, *Tetragonia expansa*, *Apium prostratum*, *Mariscus ustulatus*, *Parietaria debilis*, and *Scirpus nodosus*.

Coprosma petiolata occurs as a low prostrate shrub closely hugging the cliff. On Dayrell Islet, where the vegetation is much exposed, the plants are stunted and about 1 m. high, with exceedingly dense foliage of small rolled leaves. On Fleetwood Bluff the leaf-blades of a male plant measured 53 x 24 mm., 54 x 26 mm., 51 x 28 mm., were shining, light green, cori-

VEGETATION OF THE KERMADEC ISLANDS.—OLIVER

VEGETATION OF THE KERMADEC ISLANDS.—Oliver.

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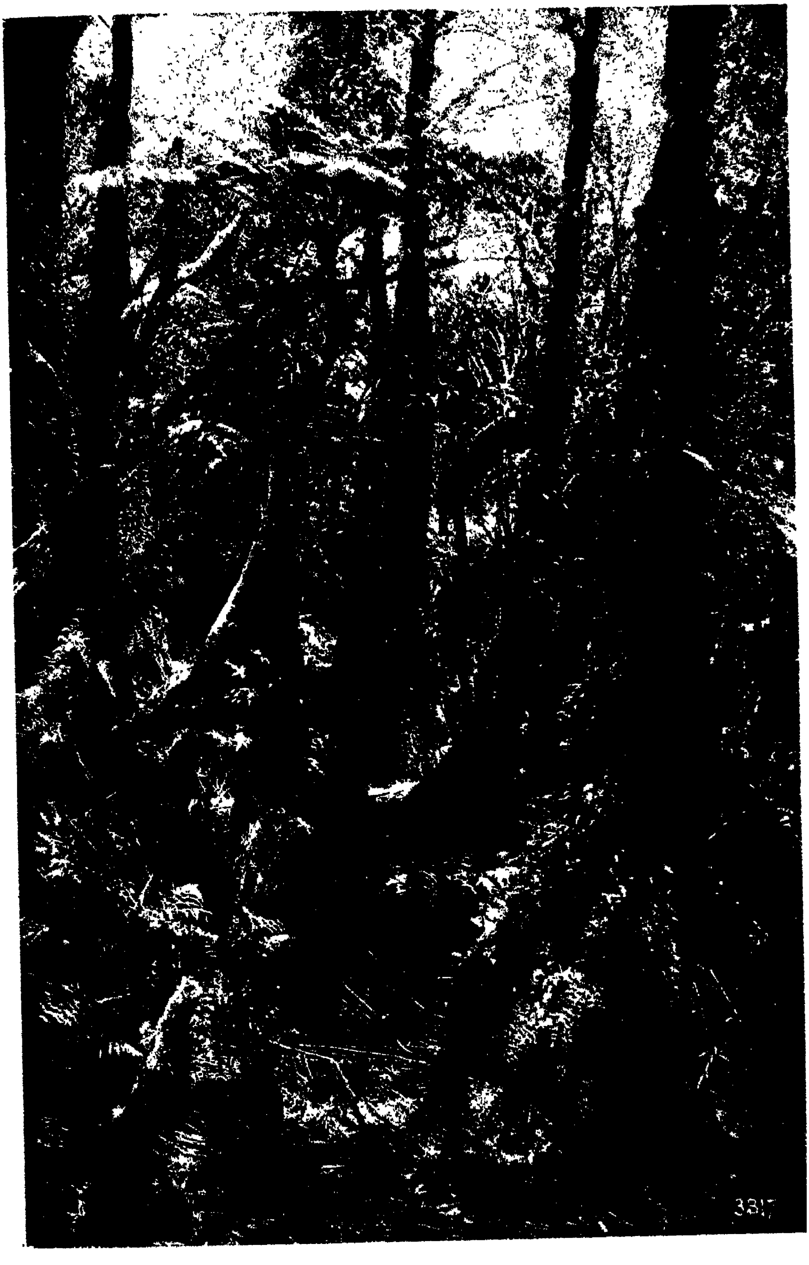
VEGETATION OF THE KERMADEC ISLANDS.—Oliver.



VEGETATION OF THE KERMADEC ISLANDS.—Oliver

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VEGETATION OF THE KERMADEC ISLANDS.—Oliver.

VEGETATION OF THE KERMADEC ISLANDS —Oliver aceous, with the margins recurved or more or less rolled. Leaves of young shoot, 70 x 34 mm., 73 x 34 mm. In exposed places on the east coast of Sunday Island the leaves were usually much rolled, the two parts of the upper surface sometimes touching underneath.

Poa polyphylla forms small tussocks of fine, drooping foliage, with abundant small, moderately dense, drooping panicles projecting beyond the foliage. Leaves narrow, 12–20 cm. long, 1·5–2 mm. broad, coriaceous, scabrid on the margins and keel. Culms crowded, length to end of panicle ± 35 cm.

Samolus repens stricta is a small subshrub with usually few erect branching stems 20–30 cm. high, bearing near their extremities small axillary white or pinkish flowers. Leaves small, 10 mm. long, 3 mm. broad, coriaceous, obovate, ending in small points.

Where a lava cliff forms the coast-line, as at the north end of Denham Bay, the plants occur in crevices or on ledges of the cliff-face. In such situations are found *Asplenium obtusatum, Samolus repens stricta, Mesembryanthemum australe, Poa polyphylla, Coprosma petiolata,* and *Lobelia anceps.*

On the north coast of Sunday Island, where the cliffs are of a loose material, and fragments are continually falling, a heap of rocks and rubble is formed at the foot. Here occur *Asplenium obtusatum, Mesembryanthemum australe, Lobelia anceps,* and *Samolus repens stricta*; while at Rayner Point *Parietaria debilis, Apium prostratum, Tetragonia expansa, Rhagodia nutans,* and *Mesembryanthemum australe* are most abundant, with a few plants of *Calystegia Soldanella* and *Mariscus ustulatus.* On slopes of tuff at the base of Fleetwood Bluff and the Terraces *Scævola gracilis, Ipomœa pes capræ,* and *Imperata Cheesemani* occur, also *Coprosma petiolata* and small prostrate shrubs of *Myoporum lætum.*

The coastal rocks on Meyer Island are particularly bare and exposed. Two or three species of lichen are abundant, and in crevices and lodgment-places for small quantities of soil the following plants are found: *Mesembryanthemum australe, Scirpus nodosus, Asplenium obtusatum, Coprosma petiolata, Mariscus ustulatus, Tetragonia expansa.*

Napier Islet is a mere rock rising 60 m. above sea-level. Here and there a crevice contains a little soil, and a few ledges on the western slope support some stunted straggling trees of *Metrosideros villosa* and *Myoporum lætum.* All these little patches of ground are being continually overturned by burrowing shearwaters and petrels, and consequently are for the most part bare. The winter mutton-bird (*Œstrelata neglecta*) also occupies a portion of the available surface for its nesting-ground. The plants collected were *Canavalia obtusifolia, Asplenium obtusatum, Mesembryanthemum australe, Sonchus oleraceus, Rhagodia nutans, Lobelia anceps, Solanum nigrum, Cotula australis, Panicum sanguinale microbachne,* and *Erigeron canadense.*

On Dayrell Islet *Mariscus ustulatus, Asplenium obtusatum, Mesembryanthemum australe, Samolus repens stricta, Rhagodia nutans, Tetragonia expansa,* and a few others occur.

The nearest land to French Rock is Curtis Island, distant 83 km. I therefore considered myself extremely fortunate in being able to land on this rock, the most southern member of the Kermadec Group, for half an hour (14th November, 1908) during the voyage back from Sunday Island. It is a mere rock, exposed in all its parts to the winds carrying salt spray, while during a hurricane the waves probably dash right over it. *Mesembryanthemum australe* was abundant near the summit, forming large green patches visible from the ship at some distance, while *Asplenium obtusatum* was also fairly common. Three other species were collected—*Senecio lautus*, a much-branched, erect, glabrous herb 25 cm. tall, with lanceolate, fleshy, lobed leaves, and rather dense many-flowered corymbs; *Deyeuxia Forsteri littoralis*, a stunted form with small short panicles; and *Parietaria debilis.*

(*b.*) Mariscus *Slopes.*—Talus slopes at the foot of sea-cliffs, and other steep slopes along the coasts, are usually covered with close-growing tussocks of *Mariscus ustulatus*, among which other plants occur in greater or lesser numbers. Next in importance to *Mariscus ustulatus* are *Carex Forsteri insularis, Pteris comans, Hypolepis tenuifolia, Scirpus nodosus*, and shrubby forms of *Myoporum lætum.*

Carex Forsteri insularis forms small tussocks, ½–1 m. high, with crowded, drooping leaves, and many semi-erect slender culms bearing numerous compound spikelets, the upper ones sessile, approximate, the lower on long erect peduncles. Leaves 1 m. long, 1 cm. broad, yellowish-green, coriaceous, margins and keel scabrid.

Talus slopes are composed of *débris* weathered off the cliff-face. The soil is thus of a loose moving nature, and, having a large proportion of stones, is not touched by burrowing birds. Other coastal slopes, however, having no cliff above them, and hence with a more stable soil, composed of the weathered surface of volcanic tuffs, are used by burrowing petrels and shearwaters for breeding-grounds during the summer months. The soil is thus everywhere being turned over for many months of the year, and in this respect resembles the moving soil of the talus slopes. Hence a similar type of vegetation is found in both stations. *Mariscus ustulatus*, whose large tussocks cannot be easily rooted up by the birds, is the principal plant, and in many places the sole occupier, of these slopes.

Talus slopes in Denham Bay support a dense covering of vegetation ± 1 m. high, composed chiefly of *Mariscus ustulatus, Ageratum conyzoides, Pteris comans, Carex Forsteri insularis*, and *Sicyos australis. Scirpus nodosus* grows in tufts along the base of the slopes just above the reach of the waves.

The steep slopes of Titi Knob, where not covered by forest, form the breeding-ground of large colonies of black-burrowers (*Puffinus chlororhynchus*) and short-billed titi (*Œstrelata nigripennis*). The whole surface not occupied by rock is disturbed every year by these two species of sea-birds. Yet it is densely covered with large tussocks of *Mariscus ustulatus*, with only here and there, except on rocky ground and cliffs, a few plants of *Hypolepis tenuifolia, Pteris comans, Carex Forsteri insularis, Myoporum lætum*, and perhaps some others.

The vegetation of Curtis Island is best described under the present heading. The inner slopes and top of the crater-ridge are covered either with *Mariscus ustulatus* or *Mesembryanthemum australe*, the two plants generally keeping separate, and each occupying a large share of the surface. Large numbers of sea-birds breed on the island. Black-burrowers and short-billed titi burrow wherever the soil is loose enough for them to move, while the masked gannet (*Sula cyanops*) lays on the surface, trampling down the *Mesembryanthemum* about its nest. When the birds leave at the end of the breeding season the vegetation profits by the amount of guano mixed with the soil, hence a rank growth covers the ground wherever the birds are able to breed. Not uncommon among the *Mariscus* tussocks on the crater-ridge were plants of *Lepidium oleraceum frondosum.* This plant occurred in the form of much-branched, rounded bushes, ½ m. or more high, with the periphery of dense foliage and numerous clusters of racemes of many small white flowers. Leaves 6–8 cm. long, rhomboid-oblong, the distal half deeply serrate. Other plants noticed on the slopes were *Scirpus nodosus, Rhagodia nutans, Parietaria debilis, Deyeuxia Forsteri, Solanum nigrum* (pubescent form), and *Sonchus oleraceus.*

(*c.*) *Ngaio* (Myoporum) *Scrub.*—Next to forest this is perhaps the most important plant association in the Kermadecs. It is essentially coastal, occupying a belt above high-water mark, from which *Metrosideros villosa* is absent. It is well developed where there is a space between the cliffs and the water's edge, as on the east coast of Sunday Island. It is found at a height of 25 m. above sea-level on the Terraces, and forms most of the vegetation of Meyer Island (highest point, 100 m. above sea-level). The original vegetation of Macauley Island was in all probability ngaio scrub, but no trace of it now remains, it having been burnt by whalers during last century, when goats were liberated for the benefit of castaways. The narrative of the discovery of the island by Captain Sever, in 1788, says, "The top of the land was covered with a coarse kind of grass, and the place affords great plenty of the wild mangrove." The coarse grass is probably *Mariscus ustulatus,* and the wild mangrove *Myoporum lætum.* In 1887 Mr. Percy Smith observed the charred stumps of some ngaio (*Myoporum lætum*), as well as a few living shrubs of the same plant (17 ; p. 26).

The principal members of the ngaio scrub are *Myoporum lætum, Pteris comans, Macropiper excelsum major, Sicyos australis, Mariscus ustulatus, Carex Forsteri insularis,* and *Canavalia obtusifolia.*

Myoporum lætum in the scrub formation is a low, spreading, irregularly branched shrub, with the trunk and branches often more or less horizontal. Foliage usually dense, with the upper surface, through which project numerous dead twigs, sloping towards the sea. Leaves 12–14·5 cm. long, 3–4·5 cm. broad, light green, thick, almost fleshy, often deeply serrate; pellucid glands scarcely visible.

The ngaio scrub is exposed to constant winds bearing salt spray. The upper surface of the foliage, therefore, slopes gradually upwards from the outer edge of the scrub, where it reaches the ground. The soil is of the driest character, and in several places completely undermined by burrowing shearwaters. On Meyer Island one colony of birds succeeds another, so that the soil never has a rest.

On the east coast of Sunday Island a belt of ngaio scrub extends from the rocky shore back for several metres to the base of the cliffs, or, in Coral Bay, to the forest proper, which begins at 10–15 m. from the shingle beach. The effect of the easterly winds on this belt is most pronounced in Coral Bay. The *Myoporum* forms a close, compact mass, beginning with plants appearing among the rocks and only a few centimetres tall, and gradually getting higher towards the forest, where the adjoining *Metrosideros* trees have the wind-shorn habit of the *Myoporum.* At 10 m. from the shingle the average height would be about 1·5 m. All twigs appearing above the general level of the foliage are killed by the wind. Intermixed among the *Myoporum* are *Macropiper excelsum major, Pteris comans, Carex Forsteri insularis, Sicyos australis,* and *Canavalia obtusifolia.* The scrub in Coral Bay extends to the limits of vegetation along the shore, so that no line can be drawn between it and rock vegetation.

The western Terrace is covered with ngaio scrub, which increases in height from the top of the sea-cliffs towards the base of the higher cliffs at the base. The soil is completely overturned once a year by black-burrowers (*Puffinus chlororhynchus*), and this has the effect of almost killing the vegetation. The plants die down so much that there is hardly a green leaf left, and they have the appearance of being dead. When the birds depart a fresh rank growth of foliage results from the large amount of guano left in the soil. In August a dense growth of young shoots covers the stems of *Myoporum lætum* and *Melicope ternata*; the tops of the trees, however, are quite dead and never recover. The undergrowth is a rank mass of *Macropiper excelsum major* about 1 m. high, and which, judging by the number of dead stems present, appears to have been killed right down to the roots. With it occur a few other plants—*Mariscus ustulatus*, *Pteris comans*, *Solanum nigrum*, *Carex Forsteri insularis*, *Sicyos australis*, *Hypolepis tenuifolia*, *Ageratum conyzoides*.

Growing in highly manured ground vacated by the shearwater above mentioned, *Sicyos australis* frequently produces abnormal male flowers, in which the petals turn green, and assume more or less the shape and character of young foliage-leaves.

The vegetation on Meyer Island takes the form of open ngaio (*Myoporum*) scrub up to about 8 m. high, and including some other trees not characteristic of this formation—*Metrosideros villosa*, *Corynocarpus lævigata*, *Pisonia Brunoniana*, *Rapanea kermadecensis*.

Pisonia Brunoniana branches in an extremely irregular, not to say fantastic manner. The trunk is stout, gnarled, and divided half a metre or so above the ground. The stems spread out in all directions, and, branching but few times, bear a rosette of large leaves at the extremity of each twig. Often large branches are dead. The *Pisonia* appears to have a hard struggle to live on this exposed arid islet. On every possible spot a white-cap noddy (*Micranous leucocapillus*) has placed its nest built of *Pisonia* and other leaves. Whether or not the bird plucks leaves from the trees for its nest I cannot say.

There are a few small plants of *Corynocarpus lævigata* growing in the most sheltered places on Meyer Island. They have erect stems, small, dark, yellowish-green upper leaves and larger lower ones, and never rising higher than the surrounding ngaio scrub; their uppermost twigs are dead.

Asplenium Shuttleworthianum on Meyer Island is a low densely tufted fern. Rhizome stout, brownish-black, forming a mass 15–20 cm. in diameter. Fronds crowded, much divided, the pinnæ usually overlapping, with short segments, yellowish-green, the tips usually dead.

The soil on Meyer Island is the loose shifting, yellowish weathered surface of the tuffs of which the island is composed. It is continually being overturned by burrowing species of shearwater. During the summer months the burrows are occupied by *Puffinus chlororhynchus*, in company with a small petrel (*Œstrelata nigripennis*), while for the remainder of the year their place is taken by *P. assimilis*. It is only in crevices of rocks and other places where the birds are unable to burrow that any small plants occur. Here are found *Sicyos australis*, *Canavalia obtusifolia*, *Parietaria debilis*, *Mariscus ustulatus*, *Solanum nigrum* (pubescent form), *Asplenium Shuttleworthianum*, and *Siegesbeckia orientalis*.

The scrub, owing to the steep rocky nature of the surface, is rather open. The *Myoporum* itself appears to be as much dead as alive. Looking at it from above, one sees a forest of straggly dead brushwood, among which living branches are struggling for existence. The constant winds laden with salt spray are too severe, the result being that the upper exposed twigs of all the trees are dead.

The top of Dayrell Islet supports a very scanty vegetation. The soil is everywhere undermined by burrowing shearwaters, and is in every way similar to the steep slopes of Meyer Island. There are a few small trees of *Metrosideros villosa* of a straggly habit while *Myoporum lætum* and *Coprosma petiolata* form low dense bushes about 1 m. high.

(*d*) *Sand Dunes*.—The only true sand dunes on Sunday Island form a single line fringing Low Flat Beach on the north coast. They are low and consist of the fine sand of which the beach is composed heaped up by wind against the land. They are covered with *Ipomœa pes capræ*, which sends its runners two or three metres on to the beach itself and its long white roots still further under the beach. Among the *Ipomœa* are found chiefly *Imperata Cheesemani*, *Scirpus nodosus*, *Eleusine indica* and *Apium prostratum*.

(*e*) *Gravel Flat*.—A flat extends along the beach in Denham Bay for about 2 km., and has an average width of 75 m. Its outer edge coincides with the limit of storm seas and shifting gravel, along its inner edge is forest. The vegetation of this flat forms an important plant formation, as in Denham Bay seeds of plants brought by ocean-currents and washed ashore are most likely to find a suitable place for germinating.

The principal plants of the gravel flat are *Ipomœa pes capræ*, *Mariscus ustulatus*, *Scirpus nodosus*, *Scævola gracilis*, *Myoporum lætum*, *Ageratum conyzoides*, *Stellaria media*, *Euphorbia Peplus*, *Cynodon Dactylon*, *Calystegia Soldanella*, *Tetragonia expansa*, *Deyeuxia Forsteri*, *Imperata Cheesemani*, and *Erechthites prenanthoides*.

Ipomœa pes capræ has long, branched, trailing stems which lie along the ground rooting here and there at the nodes. Leaves large, 2-lobed, dark yellowish-green, firm in texture, forming a mass of vegetation covering the ground to a height of 30 cm. Flowers large and conspicuous, pale lilac, produced in abundance.

Scævola gracilis is a procumbent undershrub with long spreading, hairy branches, and rather dense hairy foliage, covering the ground to a height of about half a metre. Leaves 114 × 39 mm., 110 × 42 mm., 97 × 35 mm., 80 × 25 mm., yellowish-green, firm in texture, covered with short stiff hairs. Flowers small, axillary, white with a yellow centre, produced abundantly throughout the year. Fruit fleshy, white.

Myoporum lætum occurs on the gravel flat as low shrubs, 1–3 m. tall with dense light-green foliage, through which project numerous dead twigs. Detached plants only are found, with the foliage on the seaward side reaching the ground.

The gravel flat is said to be covered by hurricane seas only, though other heavy seas sometimes break over parts of it killing some of the vegetation. In July 1908 the sea flooded part of the flat and killed *Ipomœa pes capræ* and some of the leaves and twigs of *Myoporum lætum*.

The soil is gravel, similar to that of which the beach is composed. During westerly weather it is continually drenched with salt spray.

From October till April, wideawake terns (*Sterna fuliginosa*) occupy the front portion of the gravel flat, and keep the vegetation well trampled down. When they depart, however, the *Ipomœa pes capræ* grows up tall and rank, covering the ground with dense dark-green foliage to a height of 40–50 cm., and elsewhere a host of weeds, chiefly *Stellaria media* and *Euphorbia Peplus* soon springs up.

Three plants occupy practically the whole of the flat—viz., *Mariscus ustulatus*, *Scirpus nodosus*, and *Ipomœa pes capræ*. *Mariscus ustulatus* occurs all over the flat, but more sparingly near the forest, where it is replaced by *Scirpus nodosus* and *Ageratum conyzoides*. *Ipomœa pes capræ* grows almost everywhere, mixing with both *Mariscus* and *Scirpus*. Its long trailing stems are only driven back by the waves on one side and by the shade of the forest on the other. A few shrubs of *Myoporum lætum* occur here and there, while there is an undergrowth among the *Mariscus* and *Ipomœa*, chiefly composed of *Stellaria media*, *Euphorbia Peplus*, and *Cynodon Dactylon*. Along the sea-edge, where the gravel takes the nature of a dune, *Calystegia Soldanella* and *Tetragonia expansa* occur.

There is evidence that another plant—*Scævola gracilis*—now almost entirely killed by introduced sheep and cattle, formerly took an important part in the formation. In an enclosure at the south end of Denham Bay, where these animals are not allowed, the vegetation is dense, about half a metre high, and composed principally of *Scævola gracilis* and *Scirpus nodosus*, with *Ipomœa pes capræ* growing among them. Here also are found *Imperata Cheesemani* and *Danthonia pilosa*.

2. *Inland Edaphic Formations.*

The plant formations occurring in all places on Sunday Island where the nature of the soil inhibits the growth of forest (except the areas occupied by the coastal, young, and introduced formations) are included under this heading, and naturally fall into three groups, which will be described in the order of their probable appearance. Forest, being the only climatic formation, is kept under a separate heading, though true forest possibly existed on Sunday Island before there were any swamps or lakes.

(*a.*) *Rocks and Cliffs.*—On Sunday Island it may be said with regard to cliff vegetation that some of the plants now most characteristic of it are those which goats search out and suppress in the forest. This is certainly the case with *Asplenium Shuttleworthianum* and *Veronica breviracemosa*. Certain plants, however, such as *Lagenophora petiolata* and *Lobelia anceps*, are found in nearly all rocky places in the forest. Other species usually occurring in rocky situations are *Hydrocotyle moschata*, *Coprosma petiolata*, *Carex Forsteri insularis*, *Scævola gracilis*, *Cyclophorus serpens*, *Peperomia Endlicheri*, *Poa polyphylla*, *Mesembryanthemum australe*, and *Psilotum triquetrum*.

The rock-vegetation is well developed on the cliffs at the back of the Terraces. These cliffs are of an exceptionally dry character, face north, and are inaccessible to goats. Where there is a crevice or ledge affording the slightest hold for soil, plants will be found. The chief members are *Cyclophorus serpens*, *Lobelia anceps*, *Asplenium Shuttleworthianum*, *Poa polyphylla*, *Peperomia Endlicheri*, and *Mesembryanthemum australe*. A plant of *Coprosma petiolata* was also seen.

On the cliffs above Denham Bay, now, owing to the presence of inhabitants in the bay, practically free from goats, are found *Veronica breviracemosa*, *Coprosma petiolata*, *Lobelia anceps*, *Lagenophora Forsteri*, and *Carex Forsteri insularis*, besides *Hydrocotyle moschata* in damp places. On an open rocky slope *Scævola gracilis* covers the ground; mixed with it is a little *Danthonia pilosa*.

A cliff in the crater at the base of Moumoukai contains the following plants: *Poa polyphylla*, *Cyclophorus serpens*, *Scævola gracilis*, *Erechtites* *prenanthoides*, *Nephrolepis cordifolia*, *Adiantum hispidulum*, *Pellæa falcata*, *Ageratum conyzoides*, and dwarf plants of *Myoporum lætum* and *Coriaria sarmentosa*. This part was included in the area destroyed by a volcanic eruption in 1872.

At the foot of the cliffs in Denham Bay steam escapes in several places, killing the vegetation where it issues from the ground. Near by, on the warm ground, is a dense growth of plants ½–1 m. high, consisting chiefly of *Nephrolepis exaltata*, *Polypodium diversifolium*, *Paspalum scrobiculatum*, *Lycopodium cernuum*, and *Psilotum triquetrum*. The *Polypodium* and *Lycopodium* have tall erect fronds, the former measuring up to 105 cm., the latter to 83 cm., in height.

On Macauley Island deep ravines, cut through volcanic tuffs by the action of rain-water, support on their precipitous sides a little vegetation. Goats are unable to reach certain parts, and hence possibly a remnant of the original vegetation is found here. These gullies afford shelter from wind, but the porous nature of the ground allows water to percolate freely; hence the soil is usually particularly dry. The list of plants noticed in these ravines is as follows: *Boehmeria dealbata*, *Carex Forsteri insularis*, *Asplenium lucidum*, *A. obtusatum*, *Hypolepis tenuifolia*, *Poa polyphylla*, *Lobelia anceps*, *Gnaphalium luteo-album*, *Scirpus nodosus*, *Mariscus ustulatus*, and *Mesembryanthemum australe*.

(*b*.) *Swamp*.—Swamp occurs in Denham Bay and round the Blue Lake in the crater. *Typha angustifolia* grows along the edges of Tui Lake and the Green Lake, but there is no swamp formation.

The swamp in Denham Bay is situated opposite the middle of the bay, between the gravel flat and the high perpendicular cliffs some 300 m. further back. It is somewhat oblong in shape, about 600 m. long and 200 m. broad. The ground round the swamp is composed of pumiceous tuffs and gravel, derived from the cliffs, which no doubt slipped down into the bay when the sea washed their bases. The sea has since retired, being now some 400 m. from the cliffs at this part. Rain-water percolates these tuffs very quickly, but under the swamp is a layer of blue and yellow sandy clay which holds water for a considerable time, thus making possible the existence of a swamp. The surface is everywhere spongy and gives under the feet. In places, more especially after rain, water lies to a depth of 20 cm.

The principal swamp-plant is *Typha angustifolia*. Its height varies. Over the greater part of the swamp it lies between 1 m. and 1·5 m., and here the ground, though springy, will support the weight of a man. In places, however, it is tall, up to 2·6 m., and here one's legs sink in up to the knees or deeper. After the *Typha*, *Juncus effusus* is the most important plant. It grows in tufts, 1·5 m. high, and covers large patches in the drier parts of the swamp. *Blechnum capense* (75 cm. tall), *Histiopteris incisa*, and *Paspalum scrobiculatum* occur in small patches in several places. The *Histiopteris* forms rather dense patches ± 1 m. high, with much decayed vegetable matter underneath. Other swamp-plants noticed were *Juncus pauciflorus* near the edge, and *Heleocharis acuta* in water.

The character of the vegetation in the Denham Bay swamp appears to be altering, forest-plants taking the place of swamp-plants. In fact, a swamp formation is here in process of being changed into forest. Thirty years ago there was an open sheet of water with *Typha angustifolia* growing along the edge, from where gradually it spread until now there is no open water. Parts, however, are much wetter than the rest, and here the *Typha* is tallest. In the greater part of the swamp the following appear to be signs of drying up: *Typha angustifolia* is of small size; *Juncus effusus* is abundant; various other plants, such as *Mariscus ustulatus*, *Ageratum conyzoides*, and *Polypodium diversifolium*, are appearing; and, finally, plants of *Metrosideros villosa* up to 2 m. in height occur in various places, chiefly on the higher ground, where water does not actually lie on the surface. The cause of this change is probably the filling-in of the swamp by material washed into it by rains.

The swamp surrounding the Blue Lake is similar to that in Denham Bay, but contains fewer species of plants. Besides *Typha angustifolia*, *Mariscus ustulatus* and *Paspalum scrobiculatum* are the chief plants. This swamp is of recent origin, as the water in the Blue Lake was probably boiling during the eruption of 1872, there being a number of standing dead trees near its shores.

(*c.*) *Lakes.*—From the edge of the Green Lake the bottom slopes steeply into deep water. In places, however, there is a shelf just submerged, and here *Typha angustifolia* finds a foothold; but in all cases there is a space of about a metre between it and the water's edge, this being the distance goats are able to reach when standing in shallow water.

Tui Lake is a small sheet of fresh water surrounded by forest, and lies on the edge of the area affected by the eruption of 1872. A little *Typha angustifolia* occurs, and *Callitriche Muelleri* grows either entirely submerged or on the bank close to the water's edge.

3. *Forest Formations.*

(*a.*) *General Remarks.*—Practically the whole of Sunday Island is covered with forest, this being the true climatic plant formation. The proportion of ground occupied by other formations would be insignificant when compared to that under forest, which reaches from the water's edge to the tops of the highest hills, were it not for certain disturbing influences which may be termed accidental, and which have led to the existence of the plant formations described below as "young" and "introduced." But climate, being a permanent unchanging factor, must in the long-run overcome any temporary disturbing influences, and consequently forest will gradually replace the new formations. This process is certainly going on with regard to the young formations, which might appropriately be called young forests; but the occupation of man, which is responsible for the existence of the introduced formations, may become a permanent factor ever preventing the forest regaining its lost ground. I have already mentioned the change which is apparently taking place in the swamp in Denham Bay; but this is a slow, natural process consequent on the filling-in of the swamp by material washed into it by rains, and, possibly, the gradual upheaval of the Kermadec Islands plateau.

Though small, Sunday Island is hilly in the character of its surface, and a considerable area is over 300 m. above sea-level; hence the amount of atmospheric precipitation is not the same in all parts, and consequently the character of the forest varies. The soil is everywhere extremely permeable, so that it may be disregarded as a factor determining the distribution of the main types of forest. The more elevated parts of the island undoubtedly receive a much greater amount of moisture than the lower parts. In northerly weather everywhere above an altitude of about 300 m. is enveloped in clouds, while the lower ground receives moisture only while it is actually raining, and between showers may even be suffering from the desiccating effect of the wind.

The forest, then, may be divided into two main types, determined by the amount of moisture received. To these I apply the terms "dry" and "wet." I might also refer to them as "upper" and "lower"; but, though the wet forest is confined to the upper parts of the island, its existence as a distinct formation is not due directly to its altitude, but to its abundant supply of moisture.

Generally speaking, the wet forest occurs on ground more than 250 m. above sea-level, though no sharp line of demarcation can be drawn between the wet and dry forests, the one passing gradually into the other at an altitude varying between 200 m. and 300 m. It differs from dry forest in its much more luxuriant growth, and in the abundance of cryptogamic epiphytes.

(*b.*) *Leading Physiognomic Plants and their Life-forms.*—(1.) Trees and shrubs: *Metrosideros villosa* occurs in two principal forms. Its ordinary state is a lofty forest-tree, 20 m. tall, with an erect, more or less crooked or twisted trunk ½–1 m. in diameter at the base, and branching, chiefly in its upper part, in a most irregular manner. Aerial rootlets are usually given out from the lower part of the trunk. These grow downwards, increasing in size and branching till they reach the ground, where they take root, and, still growing larger, act like additional stems.

The larger trees on the ridges and in exposed places usually have immense prostrate trunks, sending up several branches each the size of a large tree. Aerial roots are given off from the under-side of the trunk until the base of the tree becomes a mass of entangled roots and stems of all sizes. In leaning trees they form supports for the trunk, which thus spreads in the direction in which it is leaning—usually downhill or in a northerly direction—that is, away from the point whence come the hurricanes.*

Corynocarpus lævigata is a lofty forest-tree, 20 m. tall, with one to three erect stems, branching chiefly about 8–10 m. above the ground. The three trunks of one tree measured 115 cm., 135 cm., and 150 cm. in circumference respectively. Bark dark brown, rather rough, with small lenticels. Foliage dense.

Myoporum lætum is a lofty forest-tree, 20 m. tall, with a trunk 2 m. in circumference at the base, branching near the top, and with lax foliage. Bark rough, grey. Leaves serrate, light green, pellucid glands scarcely visible. Usually in the forest *Myoporum lætum* is a small tree of the second tier, with an erect stem and lax foliage.

Melicytus ramiflorus in dry forest is usually a small tree with an erect branching stem and lax foliage. In wet forest, however, it is a tree of large proportions, consisting of a great many stems spreading from the base, and with the moderately dense foliage borne principally at the top. Bark nearly smooth, and of a light-grey colour.

Rapanea kermadecensis is a small glabrous tree, 6–10 m. tall, with an erect stem bearing numerous horizontal branches. Bark rather smooth, with small lenticels, reddish-grey. Wood extremely hard. Foliage dense. Leaves elliptic-oblong, coriaceous, dark green, margins wavy, more or less rolled; laminæ 42 × 20 mm., 45 × 25 mm., 60 × 27 mm., 70 × 33 mm.

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* Dr. Cockayne is of opinion (Report Bot. Surv. Stewart Island, 1909, p. 10) that *Metrosideros lucida* has under certain stimuli an hereditary tendency towards a prostrate habit.

Flowers small, in fascicles on the twigs among and below the leaves. Fruit fleshy.

Ascarina lanceolata is a tall shrub or small slender tree, with bark of a dark reddish-brown colour, and rather rough, with close lenticels. Foliage dense; leaves ovate-lanceolate or oblong-lanceolate, deeply serrate, firm in texture, aromatic: laminæ 55 × 18 mm., 62 × 24 mm., 65 × 20 mm., 65 × 22 mm. Flowers unisexual, in compound spikes. Fruit a small drupe, 3 mm. long.

Melicope ternata is a small erect tree, 10 m. tall. Bark rather rough, with numerous lenticels, reddish. Leaves trifoliate, in bunches at the end of the twigs; leaflets large, the central ones 15 cm. long, 7·5 cm. broad, shining, flaccid, or the older ones firm.

Coprosma acutifolia is a small, erect, often slender tree, 7–10 m. tall, and with a trunk sometimes 140 cm. in circumference near the base. Bark quite smooth, grey to greenish. Branches ending in numerous slender twigs bearing moderately dense foliage. Leaves ovate-lanceolate to elliptic-ovate, acuminate, variable in size and shape; lamina 43 × 18 mm., 63 × 22 mm., 75 × 35 mm. Fruit small orange-red drupes, produced copiously.

Macropiper excelsum major is a small shrub, 2–3 m. tall, with usually several stems springing from the same base. Stems smooth, greenish, terete, with large nodes. Foliage lax. Leaves large, cordate, with 7–13 ribs radiating from the base, flaccid or moderately firm in texture; laminæ 12 × 11 cm. to 16 × 19 cm. (largest leaf measured 17 × 22 cm.). Flowers diœcious; male spikes 15–23 cm. long, female spikes 8–10 cm. long. Fruit fleshy.

(2.) Palms: *Rhopalostylis Baueri* has a stout, erect, terete, greenish trunk, marked by conspicuous regular rings representing leaf-scars. Base of stem enlarged, bearing densely crowded short roots. Height to flowers 7–10 m. Flowers borne at the base of the leaf-sheaths, several succeeding one another in a season. Leaves pinnate; length without sheath 3·5 m., longest pinnæ 1–1·2 m., forming a crown at the top of the stem spreading at an angle of ± 130°.

(3.) Tree-ferns: *Cyathea kermadecensis* has a trunk 15–20 m. tall, the base large, 1–2 m. in diameter, formed of adventitious rootlets and rapidly narrowing into a slender upper part which is comparatively smooth, as the fallen fronds leave clean scars.

Cyathea Milnei has a stout erect trunk 4–8 m. tall, slightly thickened by adventitious rootlets at the base. Fronds after withering hang down the stem for a considerable time, hence there is always a cluster of dead fronds round the top. When they do fall they break off short, leaving the broken stipes attached to the trunk, which consequently is rough and untidy.

(4.) Small ferns: *Pteris comans* forms tufts about 2 m. tall, containing many dead stipes besides the living fronds.

Nephrolepis exaltata has a short erect rhizome from which fronds and roots spring crossing one another. Height 1–2 m. A frond measured—stipe, 100 cm.; frond, 113 cm.; total length, 213 cm.; longest pinna, 175 × 17 mm. Pinnæ easily broken, so that perfect specimens are rare.

Nephrolepis cordifolia is a low fern with a tufted rhizome bearing 6–10 live and many dead fronds, and numerous roots forming a tangled mat. Fronds linear, 50–60 cm. long, 5–6 cm. broad, with the pinnæ usually broken near their tips.

Polystichum aristatum has a long creeping rhizome bearing at short intervals erect, hard, dark-green, deltoid fronds, 1 m. tall.

Dryopteris setigera is a tall fern, 1–2 m. high, with a short tufted rhizome and few, light-green, delicate, compound, deltoid fronds.

Diplazium japonicum is a low tufted fern, about ½ m. tall, with few light-green, delicate, pinnate fronds.

Blechnum capense varies very much in its size and habit. It may be a tall fern with erect fronds 2–2·5 m. high, or a low fern, ½ m. tall, with broadly ovate or nearly orbicular spreading fronds.

(c.) *Ecology.*—(1.) Ecological factors: First in importance of factors determining both the existence and character of the forest is climate. An abundant supply of rain spread throughout the year produces a forest formation whose physiognomy alters in accordance with the amount of moisture received. A full account of the climate has already been given. The annual rainfall, amounting to over 1,700 mm. for nine months, and high average degree of relative humidity, with a temperature never falling below 8° C., and averaging more than 18° C., is ample to produce hygrophytic vegetation (16; p. 168), while the desiccating effect of the constant winds is to a certain extent counterbalanced by the moisture-laden atmosphere. The winds are most felt near the sea-shore and at the top of sea-cliffs, where the vegetation is shorn down to a certain height, above which nothing but dead twigs project.

The general effect of the warm and humid climate on the vegetation is to promote a luxuriant growth. This is exemplified in the case of New Zealand plants extending to the Kermadecs. *Macropiper excelsum* and *Melicope ternata* are each represented by varieties characterized by larger leaves. *Corynocarpus lævigata* and *Myoporum lætum*, small trees in New Zealand, are on Sunday Island lofty forest-trees 20 m. tall. The habit of two plants—*Calystegia Soldanella* and *Ipomœa palmata*—of flowering but not fruiting (according to my observation) is perhaps occasioned by the climate. Some mosses rarely bear fruiting capsules.

A number of plants flower immediately after fruiting. In the case of *Rapanea kermadecensis* both flowers and ripe fruit are sometimes seen on the same twig. Besides this species, *Coprosma petiolata*, *C. acutifolia*, *Macropiper excelsum major*, *Ascarina lanceolata*, and *Melicope ternata* flower during the winter months. The slight fall in temperature, rather than interfering with, seems to favour the development of the reproductive organs (see 16; p. 48).

In the list of indigenous plants I have recorded the measurements of large specimens of several plants.

The most noticeable effect of winds is to limit the general level of the vegetation in exposed places. *Myoporum lætum*, which is the principal plant in the coastal scrub, adapts itself precisely so as to offer least resistance to the prevailing winds. Its slanting flat top is maintained by the constant winds, which, laden with salt spray, kill every twig above a certain level, determined by the density of the foliage. On the tops of cliffs, where the wind strikes with full force, the foliage is shorn down to a certain height, above which only dead twigs project.

Soil is a factor second in importance only to climate. There is little variety of soils on Sunday Island, any difference between one and another consisting in the proportions of vegetable matter contained in each. The soil everywhere consists of the more or less altered—by weathering and admixture of vegetable humus—surface of tuffs composed for the most part of pumice. The tuffs themselves are of an extremely porous character, and any noticeable water-holding capacity the soil may possess is due to the addition of humus. The nature of the soil, then, is such as to hinder the growth of forest, which depends as a formation on an abundant supply of atmospheric moisture.

On the lower more level ground a layer of black loam 10–20 cm. deep rests on pumice tuffs. Water percolates freely; hence the ground is usually more or less parched. On the hilltops, however, the more abundant supply of moisture promotes a luxuriant growth, and the consequent decay of vegetation adding humus to the soil increases its water-holding capacity. No water lies on the surface, though the soil is usually moist, and a layer of dead leaves prevents it rapidly becoming dry. On the hillsides the weathered surface of the tuffs forms the soil.

The density of the forest-roof, by regulating the supply of rain and light, has a direct bearing on the distribution of the undergrowth. The vegetation on the forest-floor varies from a dense growth of ferns 2 m. high to a few scattered ferns and seedlings, whilst in places it is entirely absent, there being only dead leaves and branches lying about. As a general rule, where the foliage is most dense there is little undergrowth, but where a break occurs ferns and other plants are abundant. On the hilltops, however, where clouds hang about in northerly weather, more moisture will be supplied to the undergrowth, which is therefore usually most luxuriant, notwithstanding the fact that the forest-roof may be not less dense than it is on the lower ground. In Denham Bay there is everywhere a dense undergrowth. Climatological Table II shows that on Sunday Island three-fourths of the rainfall occurs during northerly weather. Rain-clouds impinging against Big and Expedition Hills drop their moisture on the summits of these hills and on the flat in Denham Bay directly below.

(2.) Trees: The trees are all evergreens. One only exhibits partial defoliation. In the winter months *Homolanthus polyandrus* has appreciably fewer leaves on it than it has in the spring and summer. The older leaves fall away in the autumn, leaving only those on the young shoots, and usually less than 10 cm. across.

Two sizes of trees are distinguishable in the dry forest—those which form the upper or third tier of vegetation, which varies from 15 m. to 20 m. in height, and those growing in the shade of these, and forming a second tier of vegetation. Four trees are included in the first category—*Metrosideros villosa*, *Corynocarpus lævigata*, *Myoporum lætum*, *Melicytus ramiflorus*. In the wet forest a third tier of vegetation cannot be distinguished, the general height of the formation being about 10 m.

Over the greater portion of Sunday Island a moist climate and dry soil require that the trees should be able to endure frequent short droughts, and at the same time hold their own against hygrophytes. The soil decides the battle in favour of the plants least affected by drought. Rolled leaves, which I suspect are an adaptation to situations exhibiting alternately wet and dry conditions, are a conspicuous feature in the Sunday Island vegetation, not on account of the number of species, but because of the preponderance of individual plants, possessing them. In *Rapanea kermadecensis*, an important plant in dry forest, and *Coprosma petiolata*, a characteristic shrub of the coastal formations, the whole leaf rolls inwards so that opposite sides of the upper surface may be touching. Both these plants are endemic; hence the adjustment of their organs to the environment is complete.

In *Metrosideros villosa* the margins of the leaves are more or less recurved. The leaves of the three above plants agree very closely in size, shape, and texture. They are small, entire, oblong, coriaceous, with their margins recurved or more or less rolled.

In wet forest, where more hygrophytic conditions prevail, *Metrosideros* and *Rapanea* cease to be the dominant plants, and the leaves are of a less pronounced xerophilous character.

Leaf-buds are protected, probably against desiccation, in various ways. In *Homolanthus polyandrus* two imbricate bracts enclose each of the delicate young leaves until they expand. In *Macropiper excelsum* the sheathing base of the petiole of the terminal leaf contains the leaf-bud. In *Nothopanax arboreum* the bud is covered with mucilage. *Metrosideros villosa* and *Pittosporum crassifolium* have the buds covered with dense white tomentum.

Partial cauliflory is exhibited in *Rapanea kermadecensis* and *Melicytus ramiflorus.*

Diœcious flowers occur in *Melicytus ramiflorus*, *Macropiper excelsum major*, *Coprosma acutifolia*, *C. petiolata*, and *Nothopanax arboreum.*

Aerial roots are produced abundantly in *Metrosideros villosa.* The wetter the situation the greater the profusion of roots. In wet forest the prostrate trunk of a tree may be a metre above ground, supported by hundreds of large and small root props, and sending up large branches like distinct trees.

Ornithophily is exhibited especially in *Metrosideros villosa*, which has flowers with a brushlike polyandrous andrœcium, and a supply of nectar at the base. The tui (*Prosthemadera novæ zealandiæ*) is certainly instrumental in effecting cross-pollination for this species. These birds are abundant on Sunday Island, and may frequently be seen, with a yellow patch of pollen at the bases of their bills, visiting the flowers of the *Metrosideros.*

Entomophily occurs with *Melicytus ramiflorus.* Lacewings were observed visiting the flowers of both male and female plants, apparently searching for nectar, which I suspect is secreted by the glandular organs at the base of the petals. The lacewing thus unintentionally carries away from the male flowers pollen adhering to the under-side of the thorax. Should the insects afterwards visit female flowers, the pollen would cling to the viscid surface of the stigma, and fertilisation be effected.

The reproductive organs of *Macropiper excelsum major*, *Homolanthus polyandrus*, *Coprosma acutifolia*, and *C. petiolata* are adapted for wind pollination.

(3.) Epiphytes: With one or two unimportant exceptions the epiphytes on Sunday Island are cryptogams. They are a conspicuous feature of wet forest, where almost every available space on trees, palms, and tree-ferns is covered with mosses and ferns. Elsewhere they are much less abundant. The large leaning stems and horizontal branches of *Metrosideros villosa* support a thick covering of mosses, among which grow a variety of ferns. In the wet forest the rough stems of tree-ferns (*Cyathea*) are often clothed with filmy ferns and mosses, whilst even the smooth stem of *Rhopalostylis Baueri* is sometimes hidden by a mantle of mosses and ferns.

The principal epiphytes are *Cyclophorus serpens*, *Polypodium diversifolium*, *Asplenium flaccidum*, *A. caudatum*, *Nephrolepis cordifolia*, *Trichomanes venosum*, *Hymenophyllum demissum*, *H. flabellatum*, *Tmesipteris tannensis*, *Lycopodium Billardieri*, *Acianthus Sinclairi*, and *Peperomia Endlicheri.*

Mention has already been made of two plants (*Metrosideros villosa* and *Nothopanax arboreum*) which frequently pass through the first stages of their development on tree-fern stems, but subsequently become connected with the ground by their roots.

(4.) Ferns: Ferns may conveniently be divided into three ecological groups—tree-ferns, filmy ferns, and other kinds.

The first group is represented on Sunday Island by two endemic species, which, however, differ in many important points.

Cyathea kermadecensis is characteristic of the wet forest, and in places is the dominant plant. What may be termed a *Cyathea* forest exists in places, where magnificent tree-ferns, 20 m. tall, form a distinct plant association, forest-trees taking but a subordinate part. The fronds are rather flaccid in texture, and in dry weather curl up their pinna-segments. As they wither they fall, leaving the top of the trunk bare, and this habit gives the fern its graceful appearance. Adventitious roots are developed at the base of the trunk until it assumes large dimensions. Growing on hillsides the plants are usually leaning, and the adventitious roots are given out most abundantly on the under-side, where most of the rain-water running down the stem naturally flows before reaching the ground. Here the base of the trunk forms an acute angle, and a cross-section would be somewhat kite-shaped, about 2 m. one way and 1 m. the other.

Cyathea Milnei, the more common tree-fern in dry forest, has hard coriaceous fronds, which clothe the top of the trunk as they wither. Adventitious roots form a conical base sometimes nearly 1 m. in diameter.

The filmy ferns, of which there are four species on Sunday Island, have delicate fronds formed of but a single layer of cells. In dry weather the fronds curl up and the tips wither to a certain extent, and, if the drought be lasting, do not recover; hence it is a common thing to see these ferns with the edges of their fronds dead.

Hymenophyllum demissum is abundant everywhere in wet forest, on branches of trees, tree-fern stems, and on the ground. Large fronds measure, including the stipes, 36 cm. in length. In dry forest a few small sickly-looking plants were noticed on a log in Denham Bay. *H. flabellatum* was found in one place only—the matted roots and close fronds covering the under-side of a leaning trunk of *Metrosideros villosa* on the summit of Moumoukai. The fronds were small, 6–7 cm. long, with close overlapping segments, dead at the tips, and filiform stipes, 1–14 cm. in length.

Trichomanes humile, with fronds 7–11 cm. long, was extremely rare, being found only on wet banks and fallen trunks of tree-ferns in deep shady ravines. *T. venosum* is an epiphyte of the wet forest found only on the under-side of leaning trunks of *Cyathea kermadecensis*. In its ordinary state the frond is broadly ovate, 7–8 cm. long, 3–5 cm. broad, with a short filiform stipe 2–3 cm. long; but when growing far in under a trunk it is linear, 11–14 cm. long, 1·5–2 cm. broad, with a stipe 2·5–5 cm. long. One frond, including stipe, measured 17·5 cm. in length, 2 cm. in breadth.

Of other kinds of ferns entering largely into the forest formation *Pteris comans*, *Polystichum aristatum*, and *Nephrolepis exaltata* are the chief in dry forest. All have coriaceous fronds. In wet forest *Dryopteris glabella* and *Blechnum norfolkianum* are abundant. The texture of their fronds is firm but scarcely coriaceous, and in their young states very delicate. *B. norfolkianum* often has a small erect rhizome 10 cm. high, bearing the fronds in a tuft near the top.

(*d.*) *Physiognomy.*—The wet-forest formation covers the top of the crater-ridge from Moumoukai to Expedition Hill, and the ridges running south-west from Mount Junction to Bollons Peak, and north-west from Expedition Hill, over Big Hill, towards Hutchison Bluff. The height of this area above sea-level is mostly over 300 m., but wet forest extends below this limit on the southern sides of the ridges and in deep gullies. The remainder of the forest on Sunday Island is of the dry type. There is no sudden change noticed in ascending the hills from sea-level to their summits, as dry forest passes gradually over into wet forest. Between typical wet forest and ordinary dry forest, however, there is a marked difference. In the transition forest a mixture of plants occurs, and *Ascarina lanceolata* is found in company with *Rapanea kermadecensis* shaded by tall *Metrosideros villosa.*

(1.) Dry forest: Viewed from above, the dry forest presents a sombre appearance, the dark-green foliage of *Metrosideros villosa* alone being visible. By about June the monotony is relieved by the appearance of young shoots covered with white tomentum, and later, in October, some trees begin to flower, but not till late in November is the flowering general. Then the forest must be a blaze of red, for the scarlet flowers are produced in great profusion, but by the end of the year they are mostly over, and dull-green foliage again dominates the landscape.

The general height of the dry forest is about 20 m., and three tiers of vegetation may be distinguished. In places the forest-floor is strewn only with dead leaves and twigs, and there is no undergrowth. Usually, however, an undergrowth is present, varying in its composition in different parts. A dense growth of *Pteris comans* 2 m. high forms the lowest tier of vegetation in many portions of the island. Intermixed with this fern are *Macropiper excelsum major, Polystichum aristatum, Doodia media Milnei, Oplismenus undulatifolius, Adiantum hispidulum, Blechnum capense, Dryopteris setigera*, and other plants.

On Low Flat *Cenchrus calyculatus* is abundant, and at the base of the cliffs in Denham Bay *Hypolepis tenuifolia*, with fronds 3–4 m. tall, is plentiful.

In Denham Bay *Nephrolepis exaltata* forms an almost impenetrable mass of vegetation 1–2 m. high, with few other plants intermixed. *Polystichum aristatum* also forms the undergrowth in various parts of the island, and in Denham Bay *Nephrolepis cordifolia* claims areas to the exclusion of all other plants, its matted roots spreading over the ground, over fallen logs, and ascending the stems of tree-ferns.

Seedlings of trees, notably *Corynocarpus lævigata*, and the palm *Rhopalostylis Baueri*, often form thick patches on the forest-floor.

In Coral Bay the undergrowth is a more or less dense growth of *Macropiper excelsum major*, difficult to get through. Mixed with it is a fair proportion of *Pteris comans.* The *Macropiper* plants have each several stems, sometimes 5 m. long and 23 cm. in circumference at the base, and arched in a more or less horizontal direction.

Thus several distinct plant-communities contribute to the undergrowth in the dry forest of Sunday Island.

The second tier of vegetation is composed of small trees, palms, and tree-ferns growing in the shade of *Metrosideros villosa.* The trees are usually erect, 6–10 m. tall, branch little, and have lax foliage. They are not close together, and are altogether not so numerous as the stems of the *Metro-*

sideros among which they grow. The principal plants of this tier are *Melicytus ramiflorus*, *Rapanea kermadecensis*, *Coprosma acutifolia*, *Melicope ternata*, *Corynocarpus lævigata*, *Myoporum lætum*, *Coriaria sarmentosa*, *Boehmeria dealbata*, *Rhopalostylis Baueri*, and *Cyathea Milnei.*

Near the coast, on Low Flat and other places, *Pittosporum crassifolium* occurs, while in Coral Bay and elsewhere are clumps of *Pisonia Brunoniana*, each tree stripped of its bark as far as goats can reach.

In the more sheltered places *Rhopalostylis Baueri* forms picturesque groves. There is seldom much undergrowth where these palms are plentiful.

The third tier of vegetation in the dry forest is composed almost exclusively of *Metrosideros villosa* 20 m. tall. Two other trees, *Corynocarpus lævigata* and *Myoporum lætum*, occasionally equal the *Metrosideros* in height; while one, *Melicytus ramiflorus*, although not more than 15 m. tall, sometimes claims a share in the upper tier of foliage. There are large *Corynocarpus* trees in several places, but the giant *Myopora* were only seen in the crater and on the Terraces. A large *Melicytus* on the Terraces measured 15 m. in height, and had four principal stems, 80 cm., 110 cm., 110 cm., and 125 cm. in circumference respectively.

The forest-roof is usually fairly dense, and this factor determines the slender habit of the trees forming the second tier and regulates the distribution of the undergrowth.

Epiphytes are not a conspicuous feature in dry forest. The trunks of *Cyatheæ* occasionally support *Tmesipteris tennensis*, *Asplenium caudatum*, and *Nephrolepis cordifolia.* Branches of trees, especially the larger horizontal ones, and leaning stems, too, afford situations for a little moss, *Cyclophorus serpens*, *Polypodium diversifolium*, and *Asplenium flaccidum* (small erect form).

(2.) Wet forest: Unlike the dry forest, the wet forest is composed of a mixture of trees no one of which is predominant. Its appearance from above is varied by its different shades of green, while the graceful heads of palms and tree-ferns are thickly scattered about among the foliage. The average height on the summits of the hills is about 10 m., but in valleys and on sheltered slopes the tree-ferns (*Cyathea kermadecensis*) are 15–20 m. tall, and the forest-trees rather less.

On Moumoukai, the highest and wettest portion of the island, the forest-floor is everywhere covered with (1) mosses; (2) low ferns—*Dryopteris glabella*, *Blechnum norfolkianum*, *Polypodium diversifolium*, *Hymenophyllum demissum*; (3) dead leaves—notably *Cyathea* fronds and palm-leaves—and sticks; (4) roots of trees, fallen tree-fern stems, logs, &c., covered with mosses and the above four ferns.

Fallen trunks of tree-ferns are plentiful on the floor of the wet forest. These are invariably covered with mosses, *Hymenophyllum demissum*, *Polypodium diversifolium*, and on the under-side *Trichomanes venosum*, or perhaps *T. humile.*

On Big Hill the undergrowth is most dense, and there is a smell of rotting vegetation. *Pteris comans* is the principal plant, and its general height is 2 m. Under the *Pteris* grow *Dryopteris glabella* and *Blechnum norfolkianum.*

The trees of the upper forest grow close together, average 10 m. or more in height, and have much-branched heads of dense foliage.

Metrosideros villosa is here not the dominant tree, but is usually of large proportions, with immense prostrate trunks supported by numerous root props. The direction in which the trunk is lying is almost invariably north to north-west, and is undoubtedly the result of hurricanes which visit the islands occasionally and blow with great violence from the south-east. *Rhopalostylis Baueri* and *Cyathea kermadecensis* are abundant, and characteristic of wet forest. The principal trees are *Melicytus ramiflorus*, *Ascarina lanceolata*, *Nothopanax arboreum*, *Coprosma acutifolia*, and *Rapanea kermadecensis*. In a deep gully on Bollons Peak a single tree each of *Homolanthus polyandrus* and *Boehmeria dealbata* were noticed.

In a limited sense the plants of the wet forest group themselves into associations in which a single species is dominant. On Big Hill immense *Melicytus ramiflorus* trees, each with numerous stems, are most plentiful. On Expedition Hill and other places *Ascarina lanceolata* forms an association of tall slender trees, 8 m. in height, bearing foliage and flowers at the top only.

But the most important and distinct of the subformations is that of *Cyathea kermadecensis*. On Bollons Peak a large area is occupied by this tree-fern, associated with a few forest-trees—*Melicytus ramiflorus*, *Nothopanax arboreum*, *Ascarina lanceolata*, and *Metrosideros villosa*. The tree-ferns are growing close together, and average about 20 m. in height. The bases, composed of adventitious roots, are 1–2 m. in diameter, and often three or four unite, forming a mass 3 m. or 4 m. through. Lying about the ground are numerous fallen trunks of tree-ferns and trees, all covered, like the standing tree-ferns, with mosses and ferns. The tree-fern trunks are thickly clothed with *Hymenophyllum demissum*, *Trichomanes venosum*, *Asplenium flaccidum*, *A. caudatum*, *Polypodium diversifolium*, and mosses. *Pteris comans* and *Dryopteris glabella* form what little undergrowth there is.

The luxuriant growth of epiphytic vegetation is the main feature which stamps the physiognomy of the wet forest. A third of the species of plants noted in wet forest are epiphytes, and only two of this number (11) also occur there on the ground. The trunks and branches of forest-trees and the stems of tree-ferns and palms are clothed with mosses and ferns. Even where the forest-floor is bare of vegetation, epiphytes are not any the less abundant.

Leaning trunks and horizontal branches of trees collect a lot of soil, on which several kinds of mosses and lichens, as well as a variety of ferns and two spermophytes, flourish. The following were observed in such situations: *Polypodium diversifolium*, *Cyclophorus serpens*, *Asplenium flaccidum* (two forms), *Lycopodium Billardieri*, *Acianthus Sinclairi*, *Peperomia Endlicheri*, *Hymenophyllum demissum*.

The trunks of tree-ferns are erect but rough. As a substratum for plants they become very dry in fine weather, while no soil was observed to collect on them. In the wet forest they are nevertheless invariably clothed with various species of mosses, *Hymenophyllum demissum*, *Cyclophorus serpens*, *Asplenium caudatum*, *A. flaccidum* (two forms), and *Tmesipteris tannensis*.

On the under-side of leaning fern-trunks where rain-water does not flow none of the above plants occur, but in such places *Trichomanes venosum* is found. It alone appears to be able to obtain sufficient moisture from the atmosphere to sustain life, while in places exposed to the weather it is apparently not able to hold its own against more hardy ferns.

Palm-stems, being smooth, do not afford stations readily occupied by epiphytes. In wet forest, however, they are usually clothed with mosses, *Polypodium diversifolium*, and *Cyclophorus serpens*.

4. *Young Formations.*

In two places on Sunday Island the original dry forest has been destroyed, and young scrub or forest now occupies the ground. In Denham Bay a large landslip occurred about four years previous to my arrival. The whole face of the cliff up to 300 m. in height fell bodily forward on to the forest-covered flat below, and buried under about 10 m. of earth and rocks an area of 0·05 sq. km. About 1872—the date is uncertain—Sunday Island was in a state of eruption. From the Green Lake ashes, pumice, and boiling water were ejected, and, falling upon the forest-covered crater-floor, destroyed the vegetation. Beyond the crater it extended over Mount Campbell on to Low Flat, and altogether covered an area of about 3 sq. km.

The formations belonging to this section, here called "young" formations, are reversions (6; p. 26) to the first stages of the forest formations, with this difference: that some introduced species of plants enter into their composition, while introduced animals prevent the appearance of certain species of indigenous plants. In the next section the dominant species of plant in each formation is itself introduced.

(*a.*) *Landslip.*—The surface of the Denham Bay landslip is extremely rough, being for the most part composed of large and small blocks of lava tuffs indiscriminately piled one above another. Among these are patches of smaller stuff, gravel, &c., and it is in such places that plants obtain a footing. Everywhere except in one place, where there is a small pool in wet weather, water sinks in quickly. Logs are lying here and there, while round the edge is a belt of fallen dead trees.

The landslip is sparsely covered with vegetation—some of it with rounded shrubs, 4–6 m. tall, of *Myoporum lætum* and *Coriaria sarmentosa*, with a few small trees of *Homolanthus polyandrus* and *Boehmeria dealbata*; the remainder quite bare, or with a covering of *Ageratum conyzoides*, *Scævola gracilis*, *Mariscus ustulatus*, and small seedling *Metrosideros villosa*. Other plants noticed on the landslip were *Halorrhagis erecta*, *Veronica breviracemosa*, *Coprosma petiolata*, and *Poa polyphylla*.

(*b.*) *Tutu* (Coriaria) *Scrub.*—The soil in that portion of Sunday Island affected by the eruption of 1872 is the surface of the newly deposited pumice tuffs. It may consist purely of fragments of pumice, or a certain amount of finer volcanic ash may be present. Near the Green Lake it is a bluish-yellow clay, mostly covered with rounded pumice stones. Logs of trees are lying about here and there, while some dead stumps are still standing.

Tutu (*Coriaria sarmentosa*) scrub covers considerable areas in the crater, occupying land of the very poorest and driest kind. It is a more or less open formation, and consists principally of rounded *Coriaria* shrubs 3–5 m. tall. Near the Green Lake shrubby *Metrosideros villosa*, 1–2 m. in height, occurs. Flowering-plants ½ m. tall were observed on Naked Spur.

The ground is quite bare in places; elsewhere the vegetation is scanty. *Scirpus nodosus*, *Microtis unifolia*, *Scævola gracilis*, *Gnaphalium luteo-album*, *Ophioglossum coriaceum*, and *Imperata Cheesemani* are perhaps the plants most commonly met with, while near the Green Lake *Lycopodium cernuum* and *L. volubile* are abundant. The last plant is much sought after by goats, which eat it down close to the ground.

In a small gully from which steam was escaping in several places were found *Dryopteris parasitica* and *D. setigera*, whilst *Nephrolepis exaltata* occurred on warm ground at the foot of some cliffs.

(*c.*) *Pohutukawa* (Metrosideros) *Forest.*—*Metrosideros villosa* in the eruption area is a slender tree, usually with several stems springing from the same root; the lower branchlets are dead, and the foliage chiefly borne at the top; height, 8 m.; circumference of stems, 18–46 cm.

On the inner crater ridge the forest is composed almost exclusively of *Metrosideros* saplings 8 m. tall, growing close together. The ground is quite bare of vegetation nearly everywhere, but dead leaves and sticks are thickly strewn about. Where there is a break in the forest, *Ageratum conyzoides*, *Oplismenus undulatifolius*, &c., are found.

The gullies between this ridge and Mount Campbell are filled with ferns, chiefly young *Cyathea Milnei* and *Pteris comans.*

On the flat ground at the base of Moumoukai *Coriaria sarmentosa*, *Coprosma acutifolia*, *Myoporum lætum*, and *Cyathea Milnei* occur with *Metrosideros villosa*, while *Cyclophorus serpens* is occasionally present as an epiphyte. The undergrowth when present contains *Polystichum aristatum*, *Pellæa falcata*, and *Nephrolepis cordifolia.*

5. *Introduced Formations.*

I apply the term "introduced" to the three meadows occurring in the Kermadec Islands because in each the principal plant is an imported species. In all cases these meadows occupy ground cleared of its original scrub or forest by man. The soil, unlike that of the "young" formations, was at the time of the clearing of the forest in a fit state to receive new plants, and the existence of these formations is, in my opinion, good evidence of the superiority of plants of widespread occurrence over indigenous plants in a confined area where competition has not been keen. But climatic conditions on Sunday Island favour the growth of forest, so that, though the newcomers quickly take possession of the ground, they must eventually retreat before the encroaching forest. With regard to ground occupied by the young formations, it is in its nature so barren that indigenous species of trees (*Metrosideros villosa*, *Myoporun lætum*, *Coriaria sarmentosa*) grow as fast as introduced plants; hence the latter, suffering from the shade of the former, have not a chance of monopolizing the ground. In any case, if let alone forest will ultimately cover both areas, with introduced plants as unimportant members only.

(*a.*) Ageratum *Meadow.*—*Ageratum* meadow occupies all the clearings in the forest in Denham Bay. The chief plant is *Ageratum conyzoides*, which covers the ground to a height of about ½ m. The leaves are light green or yellowish-green; lilac-blue flowers are produced profusely throughout the year. All other plants in this formation occur more or less sporadically. The following are most commonly met with: *Dryopteris parasitica*, *Kyllinga brevifolia*, *Carex lucida*, *Sida rhombifolia*, *Vinca rosea*, and *Anthoxanthum odoratum.*

(*b.*) *Buffalo-grass* (Stenotaphrum) *Meadow.*—Buffalo-grass meadow occurs on the Terraces, on Low Flat and the adjoining crater-ridge, and in one place on the east coast. It forms a dense impenetrable mass, ½–2 m. high, with an uneven surface. It has taken almost entire possession of the ground, as only a few other plants struggle for a bare existence amongst it.

So much do the culms of the buffalo-grass (*Stenotaphrum glabrum*) intertwine, and so dense is the resulting mass, that it is only with the greatest difficulty that one can scramble over it, while walking through it is quite impossible. It is shunned by every one who has been unfortunate enough to make its acquaintance, and even goats keep clear of it, tempting though its young fresh green leaves may look. Underneath the surface is a mass of rotting leaves, damp and evil-smelling. Seedlings of other plants have little chance of growing to any size, being soon smothered by the relentless buffalo-grass. Though thousands of berries yearly fall from the palms (*Rhopalostylis Baueri*) which the grass has surrounded, there are no young plants, but rotting berries may be found in abundance.

Over parts of the Terraces one plant seems to flourish in spite of the buffalo-grass. I refer to *Ipomœa palmata*, whose long stems penetrate the dense matted grass, and, reaching the open air, trail along the surface, bearing leaves and flowers in profusion.

Certain other plants are found in the formation. Chief among these are young *Myoporum lætum* and *Metrosideros villosa* trees, the forerunners of a forest which will ultimately replace the buffalo-grass.

A few plants of *Homolanthus polyandrus*, with their upper leaves much torn by wind, are protected from goats by the very grass which almost smothers them. The leaves are large, and have much purplish-red about them; laminæ 19·5 x 21 cm., 16·5 x 18 cm.; petioles 21 cm. and 26·5 cm. respectively.

Spaces more or less clear of buffalo-grass are occupied by such plants as *Scirpus nodosus*, *Ageratum conyzoides*, *Mariscus ustulatus*, *Macropiper excelsum major*, and *Hypolepis tenuifolia*.

On Low Flat buffalo-grass meadow reaches the coast, and, partly covering some sand-dunes, includes such plants as *Ipomœa pes capræ*, *Cenchrus calyculatus*, *Scævola gracilis*, and *Imperata Cheesemani*. In places on Low Flat and the crater-ridge *Pteridium esculentum* replaces buffalo-grass.

The buffalo-grass (*Stenotaphrum glabrum*) does not spread into the forest, as want of light effectively stops progress in that direction. Like *Ageratum conyzoides*, it takes possession of the ground quicker than forest, *yet there is little doubt that now, after twenty years' occupation, the grass is being driven back by forest.* Young *Metrosideros* and *Myoporum* trees are springing up everywhere; *Cordyline terminalis* ± 2 m. tall, with wind-torn yellow or yellowish-green leaves, is also growing thickly in places. Where these plants, especially *Metrosideros*, are growing close together the buffalo-grass is dying; it is, indeed, being killed by the shadow of the trees.

(*c*.) *Beard-grass* (Polypogon) *Meadow*.—Macauley Island, once covered with *Myoporum lætum* and *Mariscus ustulatus* (see *ante*, p. 131) is now clothed only with a closely cropped and scanty mantle of grasses. No trace of the original scrub remains. The soil is formed of ashes and scoria resting on pumice. It is exposed to all winds, and consequently, except in wet weather, is usually in a parched state. At the north-east corner of the island, where the ground is a loose scoria, there is no vegetation at all.

The grass is everywhere closely cropped by the thousands of goats now roaming about the island. Nowhere is it more than a few centimetres in height. Three species were collected: *Polypogon monspeliensis* (beard-grass) appeared to be most plentiful, though *Festuca bromoides* and *Danthonia pilosa* were abundant. A few other plants only were noticed among the grass—*Oxalis corniculata*, *Cotula australis*, and *Wahlenbergia gracilis* with peduncles about 10 cm. high.

VII. Geographical Distribution.

(*a.*) *The Species.*

In the list of pteridophytes and spermophytes given in this paper 114 species are admitted as indigenous to the Kermadec Islands. Of these, 76, or 67 per cent., are flowering-plants, and 38, or 33 per cent., ferns and fern-allies.

The 114 species are referred to 88 genera, belonging to 42 families. The flora is thus most fragmentary, and characteristic of oceanic islands, whither plants are accidentally carried by ocean and air currents, and possibly other means. Twelve species, or 11 per cent., are endemic. The age of the island, therefore, will not be so great as that of Norfolk Island or Lord Howe Island, where the proportion of peculiar forms is about one-fifth and one-fourth respectively.

The relations of the Kermadec Islands plants to those of Lord Howe Island, Norfolk Island, New Zealand, Australia, and Polynesia are expressed in the following table:—

Per Cent	H., N.	New Zealand.	Australia.	Polynesia.	Endemic.
6	..	..	..	7	4
14	..	16	..	..	2
2	2	..	..	..	1
1	1	..	..	1	..
1	1	..	1	..	1
3	..	..	3	3	1
4	5	..	5	5	..
3	..	4	..	4	1
3	3	3	..	..	1
4	..	5	5	5	1
3	3	3	..	3	..
10	..	11	11	..	..
17	19	19	19	..	..
30	34	34	34	34	..
	68	95	78	62	12

The first column shows the percentage of the different constituents to the whole flora. The extensions of the plants to Lord Howe and Norfolk Islands (one or both) are shown in the second column. "Australia" means the eastern portion of the continent and Tasmania. Polynesia includes New Caledonia.

In the four central columns of the above table every species is taken into account. If a species is endemic it is counted under the headings in which its nearest related species falls. Thus *Poa polyphylla*, being closely allied to *P. anceps*, a peculiar New Zealand form, is included in the 16 shown under "New Zealand," and, as this number stands in a row by itself, it signifies that 16 species of Kermadec Islands plants, or 14 per cent. of the flora, are identical with or related to endemic New Zealand forms. Similarly *Rapanea kermadecensis*, which is related to *R. crassifolia*, occurring in Norfolk Island and Australia, is the species represented by the fifth row. The seventh row of figures shows that five species of Kermadec Islands plants are identical with species occurring in Lord Howe and Norfolk Islands (one or both), Australia, and Polynesia, but not in New Zealand. The last row shows that 34 species, or 30 per cent. of the flora, are found in all four regions named in the table; and so on. The number of species extending to each of the four regions is shown at the foot, whilst the total number occurring in the Kermadecs—namely, 114—may be obtained by adding together the numbers for each row.

The last column shows where the 12 endemic species are included in the table, and the following list is in the order in which they appear: -

Cyathea kermadecensis.
Imperata Cheesemani,
Ascarina lanceolata,
Homolanthus polyandrus,
Poa polyphylla,
Veronica breviracemosa,
Boehmeria dealbata,
Rapanea kermadecensis,
Scævola gracilis,
Coprosma acutifolia,
C. petiolata,
Cyathea Milnei.

The large Polynesian element represented in the above species seems to indicate that arrivals are less frequent from the north than from New Zealand.

Before going into details regarding the geographical relationships of the plants of the Kermadec Islands, a few remarks are necessary to clear the way. The figures given above include 38 ferns and fern-allies, which, on account of the lightness and abundance of the spores they produce, are of little value in estimating the amount of affinity of the flora with those of the surrounding lands. Again, I consider plants taking essential parts in the different formations are of more importance than those occurring sporadically, and sometimes having the appearance of having been introduced, but in the absence of direct evidence retained in the flora. As belonging to the latter category I should name *Rumex flexuosus*, *Eleusine indica*, *Kyllinga brevifolia*, *Halorrhagis erecta*, *Calystegia sepium*, *Oxalis corniculata*, *Solanum nigrum*, *Bidens pilosa*, and several others. The Australian element may be disposed of at once, and will be disregarded when considering the relationships of the plants. Of the 78 species, all but 9 are found in New Zealand, and not one Australian species does not occur in one or more of the other three regions named in the table. It is probable that no plants have reached the Kermadecs from Australia direct—a conclusion arrived at by Mr. Cheeseman after his visit to the group in 1887 (1; p. 160).

In the following remarks an endemic species is considered as equivalent in its distribution to its most closely allied species.

The 34 species of Kermadec Islands plants common to the four regions named in the above table need not be further considered. They include *Pisonia Brunoniana*, some coastal plants such as *Mesembryanthemum australe*, *Tetragonia expansa*, *Apium prostratum*, and *Sicyos australis*, 19 ferns and fern-allies, and 10 others.

As pointed out in the introduction to this paper, the Kermadec Islands form part of the New Zealand biological region. The figures given in the table leave no room for doubt on this point. To the 16 species confined to the Kermadecs and New Zealand must be added the 11 also found in Australia, making in all 24 per cent. of the flora; and assuming Lord Howe and Norfolk Islands to be part of the New Zealand region the proportion would be 47 per cent. The New Zealand species include six forest-trees (*Myoporum lætum*, *Coriaria sarmentosa*, *Corynocarpus lævigata*, *Melicope ternata*, *Nothopanax arboreum*, *Pittosporum crassifolium*), *Poa polyphylla* (end.), *Veronica breviracemosa* (end.), *Mariscus ustulatus*, *Lepidium oleraceum frondosum*, *Carex Forsteri insularis*, and 16 plants of lesser importance, one of which is a fern.

The Polynesian element in the Kermadec Islands flora is considerable, and characterizes the group as belonging to a distinct province of the New Zealand biological region. Of the 28 species not common to all the regions under consideration, 6 extend to Lord Howe and Norfolk Islands (one or both), 9 to New Zealand, and 3 to both places. This leaves 10 purely Polynesian species, of which 4 are ferns (including *Cyathea kermadecensis*). The remaining 6 are *Homolanthus polyandrus* (end.), *Ascarina lanceolata* (end.), *Scævola gracilis* (end., but affinities uncertain), and 3 grasses—*Imperata Cheesemani* (end.), *Eleusine indica*, *Cenchrus calyculatus*. Of the 9 species extending to New Zealand, 7 are ferns, 1 is *Coprosma acutifolia* (end.), and the other *Kyllinga brevifolia* (possibly introduced). Compared with the New Zealand species, the Polynesian forms in the Kermadecs must be considered weak.

(*b*.) *The Subtropical Islands Province.*

It remains to point out the relation of the Kermadec Islands plants to those of Lord Howe and Norfolk Islands. Excluding the 34 widely spread species, 34 Kermadec Islands plants are found in Lord Howe and Norfolk Islands (one or both). Of these, 22 occur in New Zealand, 6 in Polynesia, and 3 in both of these regions. The remaining 3 species are confined to the three groups of islands forming the northern province of the New Zealand region. They are *Rhopalostylis Baueri*, *Rapanea kermadecensis*, and *Boehmeria dealbata*. These plants enter largely into the forest on Sunday Island, and, while *Rhopalostylis Baueri* is found on Norfolk Island, the others are endemic, but closely related to Norfolk Island forms. The New Zealand species include *Coprosma petiolata* (end.), 4 ferns, *Scirpus nodosus*, *Heleocharis acuta*, *Microtis unifolia*, *Parietaria debilis*, *Peperomia Endlicheri*, and 12 others not taking prominent parts in the plant formations of Sunday Island. The 6 Polynesian species are *Metrosideros villosa*, *Ipomæa pes capræ*, *Canavalia obtusifolia*, 2 ferns, and *Panicum sanguinale microbachne*. Those common to both New Zealand and Polynesia are *Melicytus ramiflorus*, *Macropiper excelsum*, and *Diplazium japonicum*.

The greater part of the vegetation on Sunday Island is thus composed of plants extending to (or closely related to species in) Lord Howe and Norfolk Islands (one or both), and, of these, *Metrosideros villosa*, *Rhopalostylis Baueri*, *Rapanea kermadecensis*, *Boehmeria dealbata*, *Ipomœa pes capræ*, and others do not occur in New Zealand. Dr. Cockayne has drawn my attention to the large proportion of Norfolk Island forms in the New Zealand species found in the Kermadecs. Of the New Zealand plants on Sunday Island, 54 per cent. are also found in Norfolk Island, but of the total number of species in New Zealand only 8 per cent. extend to Norfolk Island. It is probable, then, that a number of the Kermadec Islands plants occurring in both Norfolk Island and New Zealand arrived from Norfolk Island direct; but the above figures do not express the relations quite correctly, as the whole of the New Zealand flora is made the basis of the calculation, instead of the North Island, whence only New Zealand plants could be expected to migrate to the Kermadecs.

No doubt climate determines which species shall establish themselves; hence in Lord Howe, Norfolk, and Sunday Islands, which are in nearly the same latitude, a large number of the species (48 to 60 per cent.) in each island are identical with or representative of species in the other two islands. I therefore consider the three groups of islands to form a natural province or subregion.

The numerical distribution of the plants of the Kermadec, Norfolk, and Lord Howe Islands is shown in the following tables:—

Kermadec, 114 *Species.*

Per Cent.	New Zealand.	Australia.	Polynesia.	N., L.H.
8	..	..	9	2
1	..	1	..	1
19	20	..	..	5
6	7	..	7	3
26	30	30	..	19
6	..	8	8	5
34	39	39	39	34
	96	78	63	69

Norfolk, 208 *Species.*

Per Cent.	New Zealand.	Australia.	Polynesia.	K., L.H.
5	..	..	10	4
13	..	27	..	6
7	15	..	..	5
3	7	..	7	4
19	40	40	..	25
26	..	54	54	29
26	55	55	55	45
	117	176	126	121

Lord Howe, 212 *Species.*

Per Cent.	New Zealand.	Australia.	Polynesia.	K., N.
5	..	..	11	5
23	..	48	..	6
8	17	..	..	4
1	3	..	3	2
17	37	37	..	19
23	..	48	48	25
23	48	48	48	40
	105	181	110	101

As before, the first column shows percentages, and every species is taken into account in the three central columns. The last column shows the extensions of the plants of each island to the other two islands whose plants are tabulated.

The figures for Lord Howe and Norfolk Island plants are compiled from the lists published by Mr. W. B. Hemsley (9 ; p. 221) and Mr. J. H. Maiden (13 and 14), and corrected with the further notes by Mr. Maiden in the Proc. Linn. Soc. N.S.W.

A comparison of the three tables reveals certain facts which I think can be explained by the geographical position of the islands and the known direction of prevailing winds and ocean-currents in this portion of the Pacific Ocean.

The proportion of New Zealand species decreases from east to west, while there is a corresponding increase of Australian forms in the same direction. In all cases the Polynesian element is not so important as that of either New Zealand or Australia, the proportion of Polynesian plants not extending to either of the latter regions being small. The large number of Australian plants on Lord Howe and Norfolk Islands is due to the nearness and extent of coast-line of the continent in a north-and-south direction, and consequently plants have had frequent chances of reaching, and now outnumber the New Zealand species in, these islands. The tables show that, of the 27 and 48 purely Australian forms in Norfolk and Lord Howe Islands respectively, only 6 in each case extend to the other island or the Kermadecs. It is evident that the Australian species are more of the nature of stragglers which have accidentally found their way across the ocean.

The endemic species appear to be more closely allied to New Zealand and New Caledonian than to Australian forms. Lord Howe and Norfolk Islands are in the line of migration of plants and animals (8; p. 397 : 12 ; p. 19) between Malaya and New Zealand.

In considering the distribution and relationships of the floras of Lord Howe, Norfolk, and the Kermadec Islands certain species may be disregarded—for instance, all the sporiferous plants, and a host of Australian and other species belonging to widely distributed genera. The remaining genera are here enumerated for the purpose of showing the true affinities of these insular floras.

Araucaria excelsa, R. Br., of Norfolk Island, resembles *A. Cookii*, R. Br., of New Caledonia, and *A. Cunninghamii*, Ait., of Queensland and New South Wales.

Pandanus Forsteri, C. Moore and F. v. Muell., in Lord Howe Island, is allied to a Malayan species (*P. odoratissimus*).

Freycinetia and *Cordyline* are Oriental genera reaching as far as Queensland and New South Wales in one direction, and Norfolk Island and New Zealand in another.

Howea, a genus of two species confined to Lord Howe Island, is apparently related to Australian and Malayan forms. *Clinostigma* contains one species in Lord Howe Island, and three or four in New Caledonia and Samoa.

Rhopalostylis includes two species—one in New Zealand, the other confined to Sunday and Norfolk Islands. *Hedyscepe*, monotypic in Lord Howe Island, is related to *Rhopalostylis*.

Phormium is confined to New Zealand and Norfolk Island.

The tropical genus *Boehmeria* has three closely allied endemic species in Lord Howe, Norfolk, and the Kermadec Islands (one in each group), but does not extend to either New Zealand or Australia.

Colmeiroa, a monotypic genus confined to Lord Howe Island, is allied to the endemic monotypic *Carpodetus* of New Zealand.

Carmichaelia, a characteristic New Zealand genus of nineteen species, has a twentieth in Lord Howe Island. *Streblorhiza*, endemic in Norfolk Island, is related to *Carmichaelia*.

Homolanthus is a Malayan and Polynesian genus. It extends down the east coast of Australia, to New Caledonia and Lord Howe Island, and in a peculiar species to the Kermadecs.

Corynocarpus contains two species—one in New Zealand and the Kermadecs, the other in New Caledonia and the adjacent islands.

The Norfolk Island endemic genus *Ungeria* is related to *Reevesia* of the Oriental region.

Melicytus has four species in New Zealand, one of which extends to Norfolk and Sunday Islands and Eua (a small islet in the Tonga Group).

Acicalyptus has one species in Lord Howe Island, another in Fiji, and three in New Caledonia.

Metrosideros is a Malayan and New Zealand genus. The Polynesian species, *M. villosa*, extends to New Caledonia, Lord Howe Island, and the Kermadecs.

Meryta has ten species in New Caledonia, two in Norfolk Island, one in New Zealand, and two or three in the Pacific islands.

Negria, a monotypic genus confined to Lord Howe Island, is allied to *Rhabdothamnus*, monotypic in New Zealand, and both are near *Coronanthera* of New Caledonia.

Coprosma, a characteristic New Zealand genus, is represented in Lord Howe Island by three species, in Norfolk Island by three species, and in the Kermadecs by two. *C. petiolata* of the Kermadecs is closely allied to *C. Baueri* of Lord Howe Island, Norfolk Island, and New Zealand.

Lagunaria (scarcely distinct from *Hibiscus*) is monotypic in Queensland, Lord Howe and Norfolk Islands. Besides this genus only three others strictly Australian extend to Lord Howe Island. These are *Smilax*, *Notolæa*, and *Westringia*, each represented by one species, of which the *Notolæa* is peculiar. It should be pointed out that the most characteristic Australian genera are either entirely absent, or represented by one or two species only. For instance, *Acacia*, *Eucalyptus*, *Melaleuca*, *Leucopogon*, *Grevillea*, and *Hakea* together contain about 900 species, and form a large part of the vegetation in the eastern portion of the continent, yet only two species (*Melaleuca ericifolia* and *Leucopogon Richei*) have found their way to Lord Howe Island.

The floras of the three islands under consideration are fragmentary, but on account of the isolated positions of the islands this would be expected. Further, the geological structure does not support the supposition that the islands are the remnants of a large land-mass, nor does there appear to be a plant formation on any one of them that one might suspect to be a fragment of a once more extensive forest. At the same time it is impossible to believe that all the plants populating these islands have crossed the wide stretches of ocean now separating them from the nearest land-masses.

In view of the presence of the genera above enumerated, of the community of genera and species of each island with the other two, and the relation of the same to those found in the three adjacent biological regions as expressed in the foregoing tables, the following are suggested in explanation of the origin of these insular floras.

The floras of Lord Howe and Norfolk Islands are fragments of the larger one which migrated from Malaya by this way to New Zealand, received from the continental bridge stretching between New Caledonia and New Zealand, before it disappeared beneath the surface of the sea; together with a number of Australian forms which have arrived from time to time across the intervening space of ocean.

The Kermadec Islands have received their plants by transoceanic migration mainly from New Zealand, but also from Norfolk Island and Polynesia (see 1; p. 163). They are younger than Norfolk or Lord Howe Islands, but are attached to them because of the large community of species of plants with, and the possession of genera and species characteristic of, those islands.

The three groups of islands possess insular floras, are properly included in the New Zealand biological region, and together form a subregion for which is proposed the name "subtropical islands province," in contradistinction to Dr. Cockayne's "subantarctic islands province."

(c.) *The Formations.*

On an oceanic island which depends for its stock of plants on accidental migrations the flora is necessarily of a fragmentary character, and different forms arriving from various directions compete with one another for the ground. Thus a plant taking a minor part in a formation in the land of its origin may in its new home be able to compete successfully with the plants from other countries with which it comes in contact, and take a leading part in some formation. Where a small island in mid-ocean, such as Sunday Island, has received its plants from two or three equidistant fully stocked areas containing widely different assemblages of plants, one might expect the resultant plant formations to be new combinations of species. The affinities of the two most characteristic of the Sunday Island plant formations—forest and gravel flat—will be considered briefly here. In both New Zealand, Polynesian, and Lord Howe - Norfolk Island forms mingle in plant-communities which from the diverse origin of their constituents are peculiar.

The three principal plants of the gravel flat in Denham Bay are *Ipomœa pes capræ*, *Mariscus ustulatus*, and *Scirpus nodosus*. The first is a common shore-plant in most tropical countries; it occurs in Lord Howe and Norfolk Islands, but not in New Zealand. *Mariscus ustulatus* is confined to New Zealand; whilst *Scirpus nodosus* is found in New Zealand, Lord Howe and Norfolk Islands, but not in Polynesia.

Metrosideros villosa, the principal forest-tree on Sunday Island, is distributed throughout Polynesia, from New Caledonia to Tahiti and the Sandwich Islands, and also on Lord Howe Island. Should it on any of the Pacific islands take a leading part in a forest, there might be a superficial resemblance between this formation and the forest on Sunday Island; but the principal species of trees associated with it could not be identical with more than one or two of those on Sunday Island. *Rhopalostylis Baueri*, an important member of the Sunday Island forest, occurs elsewhere on Norfolk Island only. *Rapanea kermadecensis* and *Boehmeria dealbata* are peculiar to the Kermadecs, but closely related to Norfolk Island plants. *Corynocarpus lævigata*, *Myoporum lætum*, *Nothopanax arboreum*, *Melicope ternata*, and *Pittosporum crassifolium* are endemic New Zealand species. The two species of *Cyathea*, and *Ascarina lanceolata*, while not occurring in

New Zealand, may possibly be identical with Polynesian forms. *Melicytus ramiflorus* occurs in Norfolk Island, New Zealand, and Eua (Tonga Group). *Coprosma acutifolia* is endemic.

In view of the distribution of the arborescent forest-plants of Sunday Island, it follows that the forest as a formation is peculiar, contains some Norfolk Island and New Zealand forms, but most probably has greatest affinities with forest formations in certain of the islands of Polynesia. Mr. Cheeseman records (3; p. 267) that in Raiotonga *Metrosideros villosa* and *Ascarina lanceolata* grow in company.

(*d.*) *Dispersal.*

Ocean-currents have probably been the means of transporting to the Kermadec Islands the seeds of a large number of the plants now found there. The nature of the material cast up on the shores of Sunday Island points to the south or south-west as the direction from which the strongest and most frequent reach the group.

Several kauri (*Agathis australis*, Salisb.) logs, some bearing brands of New Zealand firms, are lying on the shores of Sunday Island, and on the north coast is a balk of Oregon pine supposed to have formed part of the cargo of the "Elingamite," wrecked on the Three Kings Islands in 1903. Again, during the months of July to October, 1908, when strong westerly winds prevailed, a large amount of seaweed was cast up in Denham Bay. Mr. R. M. Laing, M.A., B.Sc., has supplied me with the following names of algæ collected by me on the beaches on Sunday Island:—

D'Urvillæa antarctica,	*Hormosira Banksii,*
Carpophyllum maschalocarpum,	*Zonaria Turneri.*

All the specimens appeared to have come long distances, some having small barnacles (*Lepas*) attached, and I do not consider any of the above species are to be found living in Sunday Island waters. According to Mr. Laing, they are all New Zealand and south-east-Australian forms.

It is evident that a strong ocean-current flows from New Zealand in a north-easterly direction; and this, in my opinion, is sufficient to account for the preponderance of New Zealand forms in the flora of the Kermadec Islands.

Seeds attached to logs or trees would have a greater chance of crossing wide spaces of ocean and arriving in a fit state for germinating than if they merely floated on the surface of the water. Forest-plants especially would rely on this mode of transportation. Of nineteen kinds of seeds experimented on, I found two only floated for any length of time in salt water. These were *Ipomœa pes capræ* and *Canavalia obtusifolia*, two shore-plants widely distributed in tropical regions.

The large proportion of sporiferous plants, amounting to one-third of the flora, is suggestive of air-currents being an important factor in stocking remote oceanic islands with plants. It is a significant fact, too, that *Metrosideros villosa*, which produces an abundance of very light seeds, is widely distributed in Polynesia, and reaches some of the most distant and isolated islets. This plant is the principal tree on Sunday Island.

Birds have possibly assisted the migration of a number of plants to the Kermadecs. The tui (*Prosthemadera novæ zealandiæ*), a fruit-eating bird, is very common on Sunday Island; and a pigeon was once found there, but has since been exterminated by cats introduced by the settlers who from time to time have made their home on Sunday Island.

The following plants have berries or other succulent fruits, and some of them the tui has been observed to eat :—

Melicytus ramiflorus,	*Ascarina lanceolata.*
Rapanea kermadecensis,	*Scævola gracilis,*
Myoporum lætum,	*Rhopalostylis Baueri,*
Coprosma petiolata,	*Corynocarpus lævigata.*
C. acutifolia,	

The experiment was tried of floating fruits of the above plants in sea-water, but with most disappointing results: some of the fruits sank immediately, and none floated for more than a few days.

The harrier (*Circus gouldi*) is a regular annual visitor to Sunday Island, and a few grey ducks (*Anas superciliosa*) were seen at different times. These birds are possibly the means of carrying small seeds to the islands.

VIII. LIST OF INDIGENOUS PTERIDOPHYTES AND SPERMOPHYTES.

HYMENOPHYLLACEÆ.

Trichomanes venosum, R. Br.
Epiphyte in wet forest, Sunday Island.
New Zealand, Australia.

Trichomanes humile, Forst. f.
Damp banks and fallen *Cyathea* trunks in wet forest, Sunday Island.
Norfolk Island, New Zealand, Australia, Polynesia, Malaya.

Hymenophyllum demissum (Forst. f.), Sw.
Epiphyte and on ground in wet forest, rare in dry forest, Sunday Island.
New Zealand, Polynesia, Malaya.

Hymenophyllum flabellatum, Lab.
Epiphyte in wet forest, Sunday Island.
Lord Howe Island, New Zealand, Australia, Samoa.

CYATHEACEÆ.

Cyathea Milnei, Hook.

Hitherto only one species of *Cyathea* has been recognised from Sunday Island. Previous collectors gathered fronds of this, which, though not so tall, is far less abundant than the following species, and in references to *C. Milnei* both species have been confused. Thus the statement made by Mr. Cheeseman (1 ; p. 154)—" A fine tree-fern (*Cyathea Milnei*) which is peculiar to the islands is also very plentiful, especially towards the tops of the hills, and in all the ravines. It is often 50 or 60 feet in height, and is thus quite equal in stature to our *Cyathea medullaris,* which it much resembles "—is wholly true of *Cyathea kermadecensis,* but entirely inapplicable to *C. Milnei.* A full description of the latter species will therefore be given here.

Trunk stout, short, 2–8 m. tall ; rough with the broken-off bases of old stipes, and clothed at the top with hanging withered fronds ; base of aerial rootlets conical, 50–80 cm. in diameter.

Fronds numerous, horizontally spreading, 2·5–4 m. long, 1·2 m. broad, coriaceous, upper surface hard and shining, dark green, paler beneath. Stipes stout, clothed at the base with copious linear brown scales ; under-surface with close hard tubercles; rhachides and costæ green, slightly grooved above, asperous chiefly on the under-surface, sparingly covered with yellowish-brown deciduous wool intermixed with membranous scales.

Primary pinnæ 45–60 cm. long, 20–23 cm. broad, oblong-lanceolate. abruptly terminating in an attenuated point; secondary pinnæ 11–12·5 cm. long, 2–2·5 cm. broad, linear-oblong, falcate, narrowing gradually to an attenuated deeply serrated point; deeply pinnatifid or pinnate. Segments 12–15 mm. long, 4 mm. broad, oblong, falcate, acute, obscurely crenate-serrate, sometimes the distal portion distinctly serrate, margins slightly recurved, under-surface often scaly pubescent; veins forked, free.

Sori copious, rather large, 0·8–0·9 mm. in diameter, nearer the costule than the margin. Indusium membranous, splitting irregularly, persistent.

Forest (most abundant in dry forest), pohutukawa forest (crater), Sunday Island.

Endemic.—The fronds closely resemble those of *C. medullaris* of New Zealand, Australia, and the Pacific islands.

Cyathea kermadecensis, n. sp.

Caudex gracilis, 15–20 m. altus. Frondes 3–4 m. longæ, 70–90 cm. latæ, bi-tripinnatæ, subcoriaceæ v. fere membranaceæ, flaccidæ. Stipites rhachidesque graciles, basi squamis fuscis lineariis vestiti, supra alte canaliculati, virides, lana flavofusca et squamis lineariis dense vestiti, subtus subasperi, fusci, lana decidua et squamis membranaceis. Pinnæ 35–45 cm. longæ, 12–14 cm. latæ, oblongo-lanceolatæ, acutæ; pinnulæ 60–70 mm. longæ, 15–18 mm. latæ, lineario-oblongæ, acutæ, profunde pinnatifidæ: segmentæ, 8–9 mm. longæ, 3 mm. latæ, oblongæ, falcatæ, obtusæ, integræ v. crenulatæ. Sori copiosi, parvi, 0·5–0·6 mm. lati. Indusium membranaceum, fimbriato-lacerum, persistens.

A magnificent species, with a tall, slender trunk, 15–20 m. high; the base composed of aerial rootlets, reaching 3 m. or 4 m. from the ground, where it may be 1–2 m. in diameter. Fronds fall away when they wither, leaving a clean scar; thus the upper portion of the trunk is comparatively smooth. The diameter, 1·5 m. from the top of a trunk 11 m. tall, was only 11 cm.

Fronds numerous, the stipes forming an angle of 100°–120° with the top of the trunk, 3–4 m. long, 70–90 cm. broad, 2–3 pinnate, subcoriaceous or almost membranous, flaccid, dull green above, paler beneath. Stipes slender, base clothed above and on the sides with copious linear brown scales; stipes, rhachides, and costæ deeply grooved above and slightly on each side, green above, brown below, upper surfaces densely covered with yellowish-brown wool intermixed with small linear scales, under-surfaces slightly asperous, sparingly covered with yellowish-brown deciduous wool and membranous scales.

Primary pinnæ 35–45 cm. long, 12–14 cm. broad, oblong-lanceolate, acute or acuminate; secondary pinnæ 60–70 mm. long, 15–18 mm. broad, linear-oblong, acute or acuminate, obscurely falcate, deeply pinnatifid. Segments 8–9 mm. long, 3 mm. broad, oblong, falcate, obtuse or subacute, entire, or finely crenulate, or the fertile segments lobulate; costules scaly pubescent; veins forked, free.

Sori copious, small, 0·5–0·6 mm. in diameter, nearer the costule than the margin. Indusium membranous, splitting irregularly, persistent.

Forest (chiefly in wet forest), Sunday Island.

Endemic. Apparently closely allied to some Polynesian species.

POLYPODIACEÆ.

Dryopteris setigera (Bl.), O. Ktze.

I have a specimen in which the costa of one of the primary pinnæ divides. Length from rhachis to fork, 6·7 cm.; of the two branches of the pinna, 14 cm. and 17 cm.

Dry forest, swamp (a few plants, fronds 50 cm. long), near fumaroles (crater), Sunday Island.

Norfolk Island, Australia, Polynesia, Malaya.

Dryopteris parasitica (L.), O. Ktze.

Dry forest, swamp (a few plants), *Ageratum* meadow, near fumaroles (crater), Sunday Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Tonga, tropics.

Dryopteris glabella (A. Cunn), C. Chr.

Rhizome small, short, tufted; fronds perfectly glabrous; lower basal secondary pinnæ of lowest primary pinnæ usually much longer than the rest.

Forest, Sunday Island.

New Zealand, Australia, Polynesia.

Polystichum aristatum (Sw.), Pr.

Dry forest, swamp, pohutukawa forest (crater), Sunday Island.

Norfolk Island, Australia, Tonga, tropics.

Nephrolepis exaltata (L.), Schott.

Dry forest (Denham Bay), on warm ground near fumaroles (Denham Bay, crater), Sunday Island.

Australia, Tonga, tropics.

Nephrolepis cordifolia (L.), Pr.

Forest, cliffs (crater), pohutukawa forest (crater), Sunday Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia, tropics.

Diplazium japonicum (Thbg.), Bedd.

Forest, Sunday Island.

Norfolk Island, New Zealand, Fiji, tropics.

Asplenium caudatum, Forst. f.

Forest, Sunday Island.

Polynesia, tropics.

Asplenium obtusatum, Forst. f.

Coastal rocks, Sunday Island. Herald Islets. Cliffs, Macauley Island. French Rock.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia, islands of the Southern Ocean.

Asplenium lucidum, Forst. f.

Dry forest, Sunday Island. Scrub, Meyer Island. Ravines in Macauley Island.

Lord Howe Island, New Zealand, Australia, Polynesia.

Var. *Lyallii*, Hook.—This form is intermediate between acutely pinnate states of *A. lucidum* (or *A. obtusatum*) and the less-divided forms of *A. Shuttleworthianum*.

Coastal rocks, Sunday Island.

Asplenium flaccidum, Forst. f.

Epiphyte in forest, Sunday Island.

New Zealand, Australia, Polynesia.

Variety.—Fronds oblong-lanceolate, pendulous, 50–60 cm. long. Epiphyte in wet forest, Sunday Island.

Asplenium Shuttleworthianum, Ktze.

A very variable species. Fronds broadly ovate, 3–4 pinnate, 30–50 cm. long, 20–25 cm. broad, coriaceous, yellowish-green, erect or pendulous. Sori copious, short. The segments are sometimes reduced to the bare costæ, expanding only to support the sori. In the typical form the secondary pinnæ are lanceolate, deeply pinnatifid or the lower part pinnate; segments linear-spathulate, divided into two or more lobes which are linear, obtuse. ± 1·5 mm. across. Sori 2–4 mm. long.

Inland rocks, Sunday Island. Scrub, Meyer Island.

Polynesia.

Variety.—Primary pinnæ ovate-lanceolate, deeply pinnatifid above, pinnate below; the secondary pinnæ stipitate, oblong, cuneate at the base, obtuse, deeply serrate; segments linear, obtuse, the lower ones two or more lobed at the tip.

Coastal rocks, Sunday Island.

The typical form of *Asplenium Shuttleworthianum* appears to be derived from *A. obtusatum* or *A. lucidum* through this variety and *A. lucidum Lyalli*. In *A. Shuttleworthianum* the frond lamina is reduced to its utmost limit.

Blechnum norfolkianum (Hew.), C. Chr.

Forest, Sunday Island. Macauley Island (Cheeseman).

Norfolk Island, New Zealand.

Blechnum capense (L.), Schlecht.

Pinnæ often partly fertile and partly sterile. Sometimes the middle third only is fertile.

Forest, swamp, Sunday Island.

Lord Howe Island, New Zealand, Australia, Polynesia, widely distributed.

Doodia media, R. Br., var. **Milnei** (Carr), Baker.

Forest, Sunday Island. Macauley Island (Cheeseman).

Norfolk Island, New Zealand, Australia, Polynesia (distribution of the species.)

Pellæa falcata (R. Br.), Fee.

Dry forest, pohutukawa forest (crater), cliffs (crater), Sunday Island. Macauley Island (Cheeseman).

Lord Howe Island, New Zealand, Australia, New Caledonia, Malaya.

Hypolepis tenuifolia (Forst. f.), Bernh.

Some large specimens occur at the foot of the cliffs in Denham Bay. One measured—stipe 129 cm., frond 211 cm., total length 340 cm.: another

—stipe 200 cm., frond 220 cm., total length 420 cm.; girth of stipe at bottom 64 mm.; length of lowest pinna 131 cm.

Dry forest, ngaio scrub, buffalo-grass meadow, landslip (Denham Bay), *Mariscus* slopes, Sunday Island. Ravine in Macauley Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia, Malaya.

Adiantum diaphanum, Bl.

Fronds 15-20 cm. long, branching near the base into 2 to 5 tapering subfalcate pinnæ.

Dry forest, Sunday Island. Cliffs, Macauley Island.

Norfolk Island, New Zealand, Australia, New Caledonia, Polynesia, Asia (trop.).

Adiantum hispidulum, Sw.

Dry forest, cliffs (crater), Sunday Island. Macauley Island (Cheeseman).

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia, Malaya.

Adiantum affine, Willd.

Forest, Sunday Island.

Norfolk Island, New Zealand, Australia.

Pteris comans, Forst. f.

Forest, ngaio scrub, *Mariscus* slopes, pohutukawa forest (crater), landslip (Denham Bay), Sunday Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia.

Pteris tremula, R. Br.

Dry forest, Sunday Island. Scrub, Meyer Island. Cliffs, Macauley Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Fiji.

Histiopteris incisa (Thbg.), J. Sm.

Swamp, dry forest (rare), Sunday Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, tropics.

Pteridium esculentum (Forst. f.), Cockayne.

Dry forest, buffalo-grass meadow, Sunday Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia, southern regions.

Polypodium diversifolium, Willd.

P. Billardieri, Cheeseman (not R. Br.), Manual N.Z. Flora, 1013.

Forest, swamp, warm ground (Denham Bay), Sunday Island.

Norfolk Island, New Zealand, Australia, New Caledonia.

Cyclophorus serpens (Forst. f.), C. Chr.

Forest, inland rocks, cliffs (crater), epiphyte in pohutukawa forest (crater). Sunday Island.

Norfolk Island, New Zealand, Australia, New Caledonia, Polynesia.

OPHIOGLOSSACEÆ.

Ophioglossum coriaceum, A. Cunn.
Open ground in tutu scrub (crater), Sunday Island.
Norfolk Island, New Zealand, Australia.

LYCOPODIACEÆ.

Lycopodium Billardieri, Spring.
Epiphyte in wet forest (rare in dry forest), Sunday Island.
New Zealand, Polynesia.

Lycopodium cernuum, L.
Warm ground (Denham Bay), tutu scrub (crater), Sunday Island.
New Zealand, Australia, Tonga, tropics.

Lycopodium volubile, Forst. f.
Tutu scrub (crater), Sunday Island.
New Zealand, Australia, New Caledonia, Polynesia, Malaya.

Tmesipteris tannensis, Bernh.
Epiphyte on *Cyathea* trunks, forest; rare on damp banks in wet forest, Sunday Island.
Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia.

Psilotum triquetrum, Swartz.
Dry forest, inland rocks, warm ground (Denham Bay), Sunday Island.
Norfolk Island, Lord Howe Island, New Zealand, Australia, Tonga, tropics.

TYPHACEÆ.

Typha angustifolia, L., var. **Brownii** (Kunth.), Graeb.
Swamp, shores of lakes, Sunday Island.
Norfolk Island, New Zealand, Australia, trop. and temp. regions.

GRAMINEÆ.

Imperata Cheesemani, Hack.
Cliffs, sand dunes, coastal rocks, gravel flat, tutu scrub (crater), buffalo-grass meadow, Sunday Island.
Endemic. Allied to *I. exaltata*, Brong.

Panicum sanguinale, L., var. **microbachne** (Presl.), Hack.
Buffalo-grass meadow, Sunday Island. Scrub, Herald Islets.
Norfolk Island, Lord Howe Island, Australia, Tonga, warm regions.

Oplismenus undulatifolius, Beauv.
Dry forest, pohutukawa forest (crater), Sunday Island. Macauley Island (Cheeseman).
Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia, warm regions.

Cenchrus calyculatus, Cav.
Dry forest, buffalo-grass meadow, Sunday Island.
Australia, New Caledonia, Tonga, tropics.

Deyeuxia Forsteri (Roem. and Schult.), Kunth.

Gravel flat, landslip (Denham Bay), Sunday Island. Macauley Island (Cheeseman).
Norfolk Island, Lord Howe Island, New Zealand, Australia.

Var. *littoralis*, Cheeseman.—Coastal rocks, Sunday Island. Curtis Island. French Rock.

Eleusine indica, Gaertn.

Sand dunes, cliffs, Sunday Island. Scrub, Herald Islets.
Australia, Tonga, tropics.

Danthonia pilosa, R. Br.

Gravel flat, open rocky spaces in forest, Sunday Island. Beard-grass meadow, Macauley Island.
New Zealand, Australia.

Poa polyphylla, Hack.

Coastal and inland rocks and cliffs, landslip (Denham Bay), Sunday Island. Cliffs, Macauley Island.
Endemic. Allied to *P. anceps*, Forst., of New Zealand.

Paspalum scrobiculatum, L.

Swamp, buffalo-grass meadow, warm ground near fumaroles (Denham Bay, crater), Sunday Island.
Norfolk Island, New Zealand, Australia, Tonga, warm countries.

Dichelachne crinita (Forst. f.), Hook. f.

Open spaces in forest, Sunday Island.
Norfolk Island, Lord Howe Island, New Zealand, Australia.

Dichelachne sciurea (R. Br.), Hook. f.

Swamp, Sunday Island. Macauley Island (Cheeseman).
Norfolk Island, New Zealand, Australia.

CYPERACEÆ.

Mariscus ustulatus (A. Rich.), C. B. Clarke.

Coastal rocks, swamp, gravel flat, ngaio scrub, *Mariscus* slopes, landslip (Denham Bay), buffalo-grass meadow, open spaces in forest, Sunday Island. Rocks and scrub, Herald Islets. Cliffs, Macauley Island. *Mariscus* slopes, Curtis Island.
New Zealand.

Kyllinga brevifolia, Rottb.

Ageratum meadow, Sunday Island.
New Zealand, warm countries.

Scirpus nodosus (R. Br.), Rottb.

Coastal rocks, gravel flat, landslip (Denham Bay), sand dunes, *Mariscus* slopes, forest, tutu scrub (crater), buffalo-grass meadow, Sunday Island. Rocks, Herald Islets. Cliffs, Macauley Island. *Mariscus* slopes, Curtis Island.
Norfolk Island, Lord Howe Island, New Zealand, Australia, S. temp. and subtrop. regions.

Heleocharis acuta, R. Br.

Swamp, Sunday Island.
Norfolk Island, New Zealand, Australia.

Carex lucida, Boott.

Mr. Cheeseman remarks on specimens I sent him—"It is unusual for these to have such a plentiful supply of male flowers at the top of the female spikelets."

Ageratum meadow, Sunday Island.
New Zealand.

Carex Forsteri, Wahl.

I follow Pastor G. Kukenthal in treating *C. semi-Forsteri*, C. B. Clarke, as not a distinct species.

My specimens appear to differ from New Zealand ones in having all the spikelets compound, and in the possession of smooth utricles with short beaks. Mr. Maiden, of Sydney, informs me that the form is closely allied to the Norfolk Island *C. neesiana*, Endl. (= *C. dissita*, Sol., var. *neesiana* (Endl.), Kuk.). Under these circumstances I feel justified in giving it a varietal name.

Var. *insularis*, n. subsp.—Spicæ 4–10, compositæ; superiores approximatæ, subsessiles, v. breviter pedunculatæ; inferiores pedunculis longis rectis; terminales omnino v. partim masculæ, reliquæ feminæ, basi masculæ. Perigynia elliptico-ovata, membranacea, rostrata breviter bifida, venis multis obscuris.

Coastal and inland rocks, ngaio scrub, forest, *Mariscus* slopes, Sunday Island. Ravines in Macauley Island.
New Zealand (distribution of species).

PALMÆ.

Rhopalostylis Baueri (Hook. f.), Wendl. and Drude.

On the hillside above Denham Bay is a plant with variegated leaves. Most of the leaves have among the green pinnæ several of a light-yellow colour.

Spadix about ½ m. long; spathes 3. Flowers from November to April.

Ripe fruit chiefly from April to September. Fruit globose, or broadly oblong, 14–16 mm. long.

Forest, Sunday Island.
Norfolk Island.

JUNCACEÆ.

Juncus effusus, L. (*J. polynathemus*, Buch.).

Swamp and damp ground (Denham Bay), Sunday Island.
New Zealand, Australia, cosmopolitan.

Juncus pauciflorus, R. Br.

Edge of swamp, Sunday Island.
New Zealand, Australia.

ORCHIDACEÆ.

Microtis unifolia (Forst. f.), Rchb.

Open ground in tutu scrub (crater), Sunday Island.
Norfolk Island, Lord Howe Island, New Zealand, Australia.

Acianthus Sinclairi, Hook. f.

Forest, Sunday Island.
New Zealand.

PIPERACEÆ.

Macropiper excelsum (Forst. f.), Miq., var. major, Cheeseman.

Flowers April to October. Ripe fruit October to February.
Forest, ngaio scrub, buffalo-grass meadow, Sunday Island.
Norfolk Island, Lord Howe Island, New Zealand, S. Polynesia.

Peperomia Endlicheri, Miq.

Two spikes with the distal ends inverted, and bearing flowers on their inner as well as their outer surfaces, were observed on plants growing among coastal rocks on Sunday Island. It occurred to me that these anomalous spikes might give some clue as to the origin of the spicate inflorescence; and its derivation from a cup-shaped receptacle by elongation and eversion is suggested.

Coastal and inland rocks, also epiphytic on trees (forest), Sunday Island.
Norfolk Island, Lord Howe Island, New Zealand.

CHLORANTHACEÆ.

Ascarina lanceolata, Hook. f.

Flowers unisexual, a male and a female in the axil of a broadly ovate, acute bract, and with a smaller bracteole on each side. Male flower a single anther, sessile, oblong, 3 mm. long, 2-celled, dehiscing longitudinally on the outer margins. Female flower placed within the anther, which falls away after dehiscing; ovary sessile, ovate, 1·5 mm. long; stigma sessile, broad.

Fruit crowded on compound spikes, several of which are usually together on the branches below and among the leaves. Drupe oblong, indehiscent, 3 mm. long, 2 mm. in diameter, white with irregular longitudinal markings of purplish-black. Exocarp succulent, exuding a purple juice when crushed. Putamen ovoid, compressed, chestnut-brown, 1·5 mm. long.

Flowers June to September. Ripe fruit January to May.
Wet forest, Sunday Island.
Endemic. (According to Mr. Cheeseman (4; p. 598), this species or a very close ally is found in Fiji, Samoa, and Rarotonga.)

URTICACEÆ.

Boehmeria dealbata, Cheeseman.

Seedling. Hypocotyle filiform, terete, whitish, 1 cm. long. Cotyledons orbicular, apex truncate or slightly indented, light green, 1·5 mm. in diameter. Stem erect, minutely hairy, ± 2 cm. to first leaves, reddish-green. First leaves ovate, acute, entire, light green, small, petiole 7 mm., lamina 9 mm. long. Second leaves broadly ovate, acute, obscurely serrate, green on both sides, petiole and principal veins reddish-green, minutely hairy; laminæ 17 x 10 mm., 22 x 13 mm.

Forest, landslip (Denham Bay), Sunday Island. Ravine in Macauley Island.

Endemic. Closely allied to *B. australis*, Endl., of Norfolk Island, and *B. calophleba*, C. Moore and F. Muell., of Lord Howe Island.

Parietaria debilis, Forst. f.

Coastal rocks, *Mariscus* slopes, Sunday Island. Scrub, Herald Islets. Macauley Island (Cheeseman). *Mariscus* slopes, Curtis Island. French Rock.

Norfolk Island, Lord Howe Island, New Zealand, Australia, temp. and trop. regions.

POLYGONACEÆ.

Rumex flexuosus, Sol.

Ageratum meadow, Sunday Island.
New Zealand.

CHENOPODIACEÆ.

Rhagodia nutans, R. Br.

Coastal rocks, Sunday Island. Herald Islets. *Mariscus* slopes, Curtis Island.

New Zealand, Australia.

NYCTAGINACEÆ.

Pisonia Brunoniana, Endl.

Forest, Sunday Island. Scrub, Meyer Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia, Malaya.

AIZOACEÆ.

Mesembryanthemum australe, Sol.

Coastal rocks and cliffs, inland cliffs, Sunday Island. Herald Islets. Macauley Island. Curtis Island. French Rock.

Lord Howe Island, New Zealand, Australia, S. Polynesia.

Tetragonia trigyna, Banks and Sol.

Cliffs on the north side of Sunday Island (Cheeseman).

Lord Howe Island and Australia (*T. implexicoma*, Hook. f.), New Zealand.

Tetragonia expansa, Murr.

Coastal rocks, gravel flat, Sunday Island. Herald Islets. Macauley Island (Cheeseman).

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia, S. America.

CRUCIFERÆ.

Cardamine stylosa, D.C.

Macauley Island (Cheeseman).
New Zealand, Australia.

Lepidium oleraceum, Forst. f., var. **frondosum**, Kirk.

Mariscus slopes, Curtis Island.
New Zealand.

PITTOSPORACEÆ.

Pittosporum crassifolium, A. Cunn.

Young leaves covered with white tomentum. Flowers dark red, hermaphrodite, produced throughout most of the year. Fruiting peduncles erect, 13–18 mm. long; capsule 2–3-valved, 13–15 mm. long.

Forest near the coast, Sunday Island.

New Zealand.

LEGUMINOSÆ.

Canavalia obtusifolia, D.C.

Ngaio scrub (Coral Bay), Sunday Island. Meyer and Napier Islets.

Norfolk Island, Lord Howe Island, Australia, Tonga, tropics.

GERANIACEÆ.

Geranium dissectum, L., var. **australe,** Benth.

Cliffs, Sunday Island (Cheeseman).

Norfolk Island, New Zealand, Australia, S. America.

OXALIDACEÆ.

Oxalis corniculata, L.

Coastal rocks, sand dunes, open places in forest, scrub, buffalo-grass meadow, Sunday Island. Beard-grass meadow, Macauley Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Tonga, cosmopolitan.

RUTACEÆ.

Melicope ternata, Forst.

Flowers April to October.

Forest, Sunday Island.

New Zealand.

EUPHORBIACEÆ.

Homolanthus polyandrus (Hook. f.), Cheeseman.

Mr. Cheeseman in 1887 recorded this tree as "not uncommon in sheltered places," and Mr. R. S. Bell, of Sunday Island, states that less than twenty years ago it was abundant in several localities. At the present time there are a few trees near the settlements and a few others in different parts of the island, all on cliffs inaccessible to goats. These animals absolutely determine the existence of the species. They eat the bark from the trunk as high as they can reach, and the tree dies in consequence. Another enemy of the tree is the larva of a small moth. This grub feeds on the leaves, causing them to die, and frequently young plants entirely stripped of their leaves may be seen.

A few seedlings were seen. Stem erect, terete, bearing prominent scars of fallen leaves, 5 cm. long. Leaves 4 or 5, broadly ovate, obtuse, base not indented, light green with reddish margins. Petioles long, 16–18 mm.; laminæ 15 × 17 mm., 17 × 20 mm. The petiole joins the leaf-blade about 1 mm. from the lower edge. Leaf-bud small, 4 mm. long.

The tree is usually 8–10 m. tall, with a stout erect stem showing scars of fallen leaves, and moderately dense foliage of delicate leaves which are light green with reddish margins. Bark roughish, light brown to grey. Branches in whorls of three to five. Twigs green, with prominent scars of fallen leaves.

All parts of the tree exude a white latex when cut or broken. Each young leaf is protected by two imbricate bracts, which fall away when the leaf expands. These bracts may be 47 mm. long. The largest male racemes, some of them 25 cm. long, do not have female flowers at their base, and their lowest pedicels are elongated. The longest raceme noticed bearing female flowers at the base was 15 cm. long. Capsules 15 mm. long, 3- to 4-celled, with a stigma to each cell. One capsule gathered had five cells. This is the only tree on Sunday Island that partially sheds its leaves. From May to July most of the leaves above 10 cm. across fall away.

Flowers September to November. Fruit was gathered in April and May, but probably matures as early as January.

Forest (rare), buffalo-grass meadow, landslip (Denham Bay), Sunday Island.

Endemic. Closely allied to *H. pedicellatus*, Benth., of Polynesia.

CALLITRICHACEÆ.

Callitriche Muelleri, Sond.

Lakes, Sunday Island.

New Zealand, Australia.

CORIARIACEÆ.

Coriaria sarmentosa, Forst. f.

C. ruscifolia, Cheeseman (not Linn.), Manual N.Z. Flora, 105.

Flowers and fruits most of the year, but chiefly during the summer months.

Forest, landslip (Denham Bay), pohutukawa forest (crater), tutu scrub (crater), Sunday Island.

New Zealand.

CORYNOCARPACEÆ.

Corynocarpus lævigata, Forst.

Flowers from September, fruit over in March.

Forest, Sunday Island. Ngaio scrub, Meyer Island.

New Zealand.

VIOLACEÆ.

Melicytus ramiflorus, Forst.

Flowers December to May. The tui (*Prosthemadera novæ zealandiæ*) is very fond of the fruit.

Forest, Sunday Island.

Norfolk Island, New Zealand, Eua (Tonga Group).

MYRTACEÆ.

Metrosideros villosa, Sm.

Flowers chiefly in November and December.

Forest, landslip (Denham Bay), pohutukawa forest (crater), tutu scrub (crater), swamp, buffalo-grass meadow, Sunday Island. Scrub, Herald Islets.

Lord Howe Island, New Caledonia, Polynesia.

HALORRHAGIDACEÆ.

Halorrhagis erecta (Murray), Schindler.

Landslip (Denham Bay), buffalo-grass meadow, Sunday Island. Macauley Island (Cheeseman).

New Zealand, Australia.

ARALIACEÆ.

Nothopanax arboreum (Forst. f.), Seem.

Wet forest, Sunday Island.

New Zealand.

UMBELLIFERÆ.

Hydrocotyle moschata, Forst. f.

Damp banks, open spaces in tutu scrub (crater), Sunday Island.

New Zealand.

Apium prostratum, Lab.

Coastal rocks, sand dunes, Sunday Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia, S. Africa, S. America.

MYRSINACEÆ.

Rapanea kermadecensis (Cheeseman), Mez.

Seedling. The exocarp is raised above the ground on the top of the hypocotyle before being cast off. Hypocotyle erect, terete, reddish, 3 cm. high. Cotyledons 2, or sometimes 3, broadly obovate or orbicular, 8–10 mm. long, obscurely serrate, dark green. First leaves broadly obovate, cuneate at the base, obtuse, distal half bluntly serrate, green, petiolate; lamina 12–15 mm. long. Following few leaves similar, but larger, and serrations more pronounced.

Flowers hermaphrodite, small, greenish with dark spots; calyx 5-lobed; lobes triangular, 1 mm. long, the edges beset with short thick hairs. Corolla divided nearly to the base into 5 lobes; lobes 2 mm. long, revolute, oblong, rounded at the apex, edges fringed with short thick hairs. Anthers sessile on the lobes of the corolla, sagittate, 1 mm. long. Ovary globose; stigma large, sessile, capitate, lobed.

Fruit globose, sunken at the top, dark purple, 1-seeded, 7–8 mm. in diameter.

Flowers from August through the summer, ripe fruit February to June (chiefly). Flowers and ripe fruit may be seen on the same twig.

Forest, Sunday Island. Scrub, Meyer Island.

Endemic. Allied to *R. crassifolia* (R. Br.), Mez., of Norfolk Island and Australia.

PRIMULACEÆ.

Samolus repens (Forst.), Pers., var. **stricta**, Cockayne.

Coastal rocks, Sunday Island. Dayrell Islet.

Norfolk Island, New Zealand, Australia, New Caledonia (distribution of the species).

CONVOLVULACEÆ.

Ipomœa pes caprae (L.), Roth.

Flowers November to April. Fasciation was noted in one plant on the north coast of Sunday Island. Fourteen stems were joined in one.

Gravel flat, sand dunes, coastal rocks, Sunday Island.

Norfolk Island, Lord Howe Island. Australia, Tonga, tropics.

Ipomœa palmata, Forsk.

Sea-cliffs, buffalo-grass meadow, Sunday Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia, tropics.

Calystegia sepium (L.), R. Br.

Waste places on Sunday Island (Cheeseman).

New Zealand, Australia, cosmopolitan.

Calystegia Soldanella (L.), R. Br.

Coastal rocks, gravel flat, Sunday Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, cosmopolitan.

SOLANACEÆ.

Solanum aviculare, Forst. f.

Forest, Sunday Island. Macauley Island (Cheeseman).

Norfolk Island, Lord Howe Island, New Zealand, Australia.

Solanum nigrum, L.

A pubescent and a glabrous variety were noticed, the former on the Herald Islets, the latter in waste places on Sunday and Meyer Islands. Macauley Island (Cheeseman). *Mariscus* slopes, Curtis Island (pubescent variety).

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia. cosmopolitan.

SCROPHULARIACEÆ.

Veronica breviracemosa, n. sp.

V. fruticosa, 1–2 m. alta, ramis ultimis subcompressis, puberulis. Folia sessilia, patula, 80–115 mm. longa, 20–27 mm. lata, elliptico-lanceolata v. oblongo-lanceolata, acuta, integra, glabra. Racemi 4–5 cm. longi, denseflori, puberuli, foliis breviores. Calyx 4-partitus, lobis ovato-lanceolatis, acutis, puberulis. Corolla 4-partita, calyce ½ longior; tubo breve calyce ½ breviora; lobis ovatis, acutis. Capsula 6 mm. longa, calyce ½ longior, late ovata, acuta, compressa, glabra.

An irregularly laxly branched shrub, about 1 m. high; branchlets green, 2-angled, puberulous. Leaves sessile, spreading, 115 × 27 mm., 57 × 19 mm., 80 × 20 mm., elliptic-lanceolate to oblong-lanceolate, acute, narrowed at the base, entire, light green, glabrous, minutely puberulous on the midrib and margins near the base. Racemes 4–5 cm. long, shorter than the leaves, flowers crowded; rachis, pedicels, and bracts puberulous. Flowers 5 mm. in diameter, white to pale lilac. Calyx 4-partite, the two inner divisions smaller than the two outer, segments lanceolate to ovate-lanceolate, acute, puberulous. Corolla 1½ times the length of the calyx; tube short, about half the length of the sepals; limb 4-lobed, lobes ovate, acute, 3 outer opposed to 1 inner. Capsule 1½ times the length of the calyx, 6 mm. long, acute, broadly ovate, compressed, glabrous.

Distinguished by the large broad leaves, racemes shorter than the leaves, and very short corolla-tubes.

Mr. Cheeseman includes this species under *V. salicifolia* in the "Manual of the N.Z. Flora," with the note that it is perhaps a distinct species.

This plant was formerly fairly plentiful, but has been almost killed out by goats, and is now found only on cliffs and other places inaccessible to those animals.

Inland cliffs, landslip (Denham Bay). Sunday Island.

Endemic. Resembles *V. macrocarpa* of New Zealand, differing principally in the shorter racemes and corolla-tubes.

MYOPORACEÆ.

Myoporum lætum, Forst. f.

Ngaio scrub. coastal rocks, forest, gravel flat, *Mariscus* slopes, landslip (Denham Bay), buffalo-grass meadow, pohutukawa forest (crater), Sunday Island. Ngaio scrub, Herald Islets. Macauley Island (Cheeseman).

New Zealand.

RUBIACEÆ.

Coprosma petiolata, Hook. f.

This species occurs in Denham Bay forest as a small tree, 4–6 m. tall, with a leaning stem covered with rough, dark-grey bark. Head rounded, foliage moderately dense. Leaf-laminæ of male plant 29 × 18 mm., 32 × 20 mm., 34 × 20 mm.; of female plant usually larger, 45 × 20 mm., 50 × 24 mm., 52 × 25 mm.

Flowers May to September. Ripe fruit January to May.

Fruit usually three in a cluster; reddish; variable in size and form; smaller ones ovoid, 7 × 6 mm., 9 × 7·5 mm.; larger ones compressed, more or less distinctly 2-lobed, 10 × 10 mm.

Coastal rocks and cliffs, inland cliffs (rare), dry forest (Denham Bay, rare), landslip (Denham Bay), Sunday Island. Coastal rocks and cliffs, Herald Islets. Macauley and Curtis Islands (Cheeseman).

Endemic. Closely allied to *C. Baueri*, Endl., of Norfolk Island, Lord Howe Island, and New Zealand; and to *C. chathamica*, Cockayne, of the Chatham Islands.

Mr. Cheeseman (1; p. 168) records *C. Baueri* from the Kermadecs. I did not see it, though I searched in the places indicated. I would suggest that the young large-leaved branches of *C. petiolata* were mistaken for it, and recommend that until authentic specimens are obtained the name be crossed off the list of plants inhabiting the Kermadec Islands.

Coprosma acutifolia, Hook. f.

Flowers May to September. Ripe fruit January to May.

Forest, landslip (Denham Bay), pohutukawa forest (crater), Sunday Island.

Endemic. Closely allied to *C. lævigata*, Cheeseman, from Rarotonga; and resembles *C. tenuifolia*, Cheeseman, from New Zealand.

CUCURBITACEÆ.

Sicyos australis, Endl.

Ngaio scrub, forest near the coast, *Mariscus* slopes, Sunday Island. Scrub, Meyer Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Polynesia, cosmopolitan.

CAMPANULACEÆ.

Lobelia anceps, L. f.

Coastal and inland rocks, Sunday Island. Herald Islets. Cliffs, Macauley Island. Curtis Island (Cheeseman). [illegible]

Norfolk Island, Lord Howe Island, New Zealand, Australia, cosmopolitan.

Wahlenbergia gracilis (Forst. f.), A. D.C.

Beard-grass meadow, Macauley Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, New Caledonia, Tonga, E. Asia, S. Africa.

GOODENIACEÆ.

Scævola gracilis, Hook. f.

Flowers and fruits profusely throughout the year.

Fruit an indehiscent drupe, axillary, solitary, sessile, ovoid, sometimes almost globose, truncate, sunken at both ends, 10·5 x 9 mm., 10·5 x 8·mm., 10·5 x 10·5 mm. Exocarp succulent, thick, white. Endocarp hard, bony, 2-celled, black, ovoid, mucronate, surface covered with indistinct longitudinal rows of nodules 5·5 x 4 mm. Seed oval, compressed, 3 x 2 x 1 mm., white. Seed-coat fitting close to the endocarp, and usually sticking to it when the seed is extracted. Embryo erect, imbedded in a fleshy endosperm, cotyledons linear.

Gravel flat, coastal cliffs, sand dunes, landslip (Denham Bay), tutu scrub (crater), open rocky places in forest, Sunday Island. Macauley Island (Cheeseman).

Endemic.

COMPOSITÆ.

Lagenophora pumila (Forst. f.), Cheeseman.

Inland rocks, Sunday Island.

New Zealand.

Gnaphalium japonicum, Thunb.

Gravel flat, landslip (Denham Bay), Sunday Island. Macauley Island (Cheeseman).

Norfolk Island, Lord Howe Island, New Zealand, Australia, Malaya.

Gnaphalium collinum, Lab.

Inland rocks, Sunday Island. Macauley Island (Cheeseman).

New Zealand, Australia.

Gnaphalium luteo-album, L.

Coastal rocks, landslip (Denham Bay), tutu scrub (crater), Sunday Island. Cliffs, Macauley Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, cosmopolitan.

Siegesbeckia orientalis, L.

Cliffs, Sunday Island. Scrub, Meyer Island.

Norfolk Island, New Zealand, Australia, Tonga, warm countries.

Bidens pilosa, L.

Ngaio scrub, *Ageratum* meadow, and waste places, Sunday Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia, Tonga, warm countries.

Cotula australis, Hook. f.

Inland rocks, Sunday Island. Rocks, Herald Islets. Beard-grass meadow, Macauley Island.

Norfolk Island, Lord Howe Island, New Zealand, Australia.

Senecio lautus, Forst. f.

French Rock.

New Zealand, Australia.

Erechtites prenanthoides (A. Rich.), D.C.

Gravel flat, inland cliffs and rocks, Sunday Island.

New Zealand, Australia.

IX. LIST OF INTRODUCED PLANTS ON SUNDAY ISLAND.

GRAMINEÆ.

Polypogon monspeliensis, Desf.
Festuca Myuros, L.
F. bromoides, L.
Cynodon Dactylon, Pers.
Dactylis glomerata, L.
Poa annua, L.
P. pratensis, L.
Lolium perenne, L.
Holcus lanatus, L.
Paspalum dilatatum, Poir.
Sporobolus indicus, R. Br.
Briza minor, L.
Stenotaphrum glabrum, Trin.
Bromus unioloides, H. B. K.
Anthoxanthum odoratum, L.

LILIACEÆ.

Cordyline terminalis, Kunth.

The Polynesian ti (*Cordyline terminalis*) occurs in several places on Sunday Island, such as Denham Bay, Terraces, and Coral Bay, all being habitable parts. There is one plant on Meyer Island, and one or two in the forest on Sunday Island. The species does not spread into the forest, but has every appearance of being a survivor of the abandoned cultivations of a native race, of whose occupation on Sunday Island there is good evidence. The Sunday Island plant appears to be a highly cultivated variety; it flowers regularly, but has never been known to bear fruit; it is propagated by means of its roots. I have no hesitation in including it among the list of plants introduced by man.

POLYGONACEÆ.

Rumex obtusifolius, L.
R. Acetosella, L.

CARYOPHYLLACEÆ.

Stellaria media, Vill.
Cerastium viscosum, L.
Silene anglica, L.
Polycarpon tetraphyllum, L.

CRUCIFERÆ.

Lepidium ruderale, L.
Brassica adpressa, Boiss.
Coronopus didymus, Sm.

FUMARIACEÆ.

Fumaria muralis, Sond.

LEGUMINOSÆ.

Trifolium repens, L.
T. pratense, L.
T. procumbens, L.
Medicago denticulata, Willd.

GERANIACEÆ.

Geranium molle, L.

EUPHORBIACEÆ.

Euphorbia Peplus, L.
E. pilulifera, L.
Ricinus communis, L.
Aleurites moluccana, Willd.

The candle-nut (*Aleurites moluccana*), like the Polynesian ti, appears to be the survivor of the abandoned cultivations of a native race. It now occurs in two places only on Sunday Island—there is a small clump of trees in Coral Bay and another on Low Flat. The trees in Denham Bay and the Terraces have been planted quite recently. It was formerly in other places, but has died out, leaving only dead fruit scattered about the ground. It is thus scarcely able to hold its ground in the forest.

MALVACEÆ.

Sida rhombifolia, L.

APOCYNACEÆ.

Vinca rosea, L.

SOLANACEÆ.

Physalis peruviana, L.
Nicotiana Tabaccum, L.
Datura Stramonium, L.

SCROPHULARIACEÆ.

Veronica arvensis, L.
V. agrestis, L.

PLANTAGINACEÆ.

Plantago major, L.
P. lanceolata, L.

COMPOSITÆ.

Ageratum conyzoides, L.
Erigeron canadense, L.
E. linifolius, Willd.
Senecio vulgaris, L.
Hypochaeris radicata, L.
Taraxacum officinale, Weber.
Sonchus oleraceus, L.
S. asper, Hill.

The following introduced species were observed on Macauley Island—*Polypogon monspeliensis*, *Festuca bromoides*, *Stellaria media*, *Erigeron canadense*; on Curtis Island—*Sonchus oleraceus*.

X. BIBLIOGRAPHY.

1. Cheeseman, T. F. "On the Flora of the Kermadec Islands." Trans. N.Z. Inst., vol. xx, p. 151; 1888.
2. ——— "On some Recent Additions to the New Zealand Flora." Trans. N.Z. Inst., vol. xxiv. p. 410; 1892.
3. ——— "The Flora of Rarotonga." Trans. Linn. Soc. (Bot.), vol. vi, p. 267; 1903.
4. ——— "Manual of the New Zealand Flora." Wellington, 1906.
5. Cockayne, L. "Some Observations on the Coastal Vegetation of the South Island of New Zealand." Trans. N.Z. Inst., vol. xxxix, p. 312; 1907.
6. ——— "Report of a Botanical Survey of the Tongariro National Park." Wellington, 1908.
7. Hackel, E. "On New Species of Grasses from New Zealand." Trans. N.Z. Inst., vol. xxxv, p. 378; 1903.
8. Hedley, C. "A Zoogeographic Scheme for the Mid-Pacific." Proc. Linn. Soc. N.S.W., vol. xxiv, p. 391; 1899.

9. Hemsley, W. B. "The Flora of Lord Howe Island." Annals of Botany, vol. x, p. 221; 1896.
10. Hooker, Sir J. D. "On the Botany of Raoul Island, one of the Kermadec Group." Jour. Linn. Soc. (Bot.), vol. i, p. 125; 1857.
11. ——— "Handbook of the New Zealand Flora," vols. i, ii. London, 1864–66.
12. Hutton, F. W. "On the Origin of the Fauna and Flora of New Zealand." N.Z. Jour. Science, vol. ii, pp. 1, 249; 1884.
13. Maiden, J. H. "Observations on the Vegetation of Lord Howe Island." Proc. Linn. Soc. N.S.W., vol. xxiii, p. 112; 1898.
14. ——— "The Flora of Norfolk Island." Proc. Linn. Soc. N.S.W., vol. xxviii, p. 692; 1904.
15. Parker, T. J., and Haswell, W. A. "Text-book of Zoology," vol. ii; 1897.
16. Schimper, A. F. W. "Plant-geography upon a Physiological Basis" (English translation). Oxford, 1903.
17. Smith, S. P. "The Kermadec Islands: their Capabilities and Extent." Wellington, 1887.
18. Tate, R. "On the Geographic Relations of the Floras of Norfolk and Lord Howe Islands." Macleay Memorial Volume. Sydney, 1893.
19. Wallace, A. R. "The Geographical Distribution of Animals," vol. i. London, 1876.

EXPLANATION OF PLATES XII TO XXIII.

PLATE XII.

Path of a hurricane through forest in Denham Bay, Sunday Island. The fallen trees are *Metrosideros villosa*. In centre, young shrubs of *Myoporum lætum*.

PLATE XIII.

Ngaio scrub, Terraces, Sunday Island, showing ngaio (*Myoporum lætum*) killed by burrowing shearwaters (*Puffinus chlororhynchus*). The undergrowth is *Macropiper excelsum major*.

PLATE XIV.

Gravel-flat vegetation, Denham Bay, Sunday Island. *Ipomœa pes capræ* in flower. Beyond, *Scirpus nodosus*.

PLATE XV.

Vegetation on inland rocks, Terraces, Sunday Island. The ferns are *Asplenium Shuttleworthianum*. On right—below, *Lobelia anceps*; above, *Cyclophorus serpens*.

PLATE XVI.

Interior of dry forest, Denham Bay, Sunday Island. On left, *Cyathea Milnei*; on right, *Rapanea kermadecensis*.

PLATE XVII.

Interior of palm (*Rhopalostylis Baueri*) forest, Big Hill, Sunday Island.

PLATE XVIII.

Interior of wet forest on Mount Junction, Sunday Island. Trunks of *Cyathea kermadecensis* covered with *Hymenophyllum demissum*, and other ferns.

PLATE XIX.

Landslip, Denham Bay, Sunday Island, showing rounded shrubs of *Myoporum lætum* and *Coriaria sarmentosa*.

PLATE XX.

Interior of pohutukawa (*Metrosideros*) forest, crater, Sunday Island. (Photo, W. L. Wallace.)

PLATE XXI.

Cyathea Milnei, Sunday Island.

PLATE XXII.

Cyathea kermadecensis, Sunday Island.

PLATE XXIII.

Flowering branch of *Rapanea kermadecensis*, Sunday Island, showing rolled leaves.

Art. XIV.—*The Mokoia Aerolite; with a Few Introductory Remarks on New Zealand Meteoric Phenomena.*

By George R. Marriner, F.R.M.S.,* Curator, Public Museum, Wanganui.

[*Read before the Wellington Philosophical Society, 4th August, 1909.*]

Though several meteoric stones have been found in New Zealand, the information concerning them is difficult of access, owing to its being published in so many different journals; therefore, before describing the recent fall at Mokoia, I would like to briefly summarise the different meteoric phenomena witnessed in the Dominion. In doing so I will include all the evidence that can be found on the Makarewa and the Wairarapa meteorites, so that future workers on this interesting subject may find the data easily available.

Numerous brilliant meteors have from time to time flashed across our sky, but, unfortunately, very few have been recorded.

Besides these, three meteoric stones have been found, and by their analyses a little more has been added to our knowledge of the heavenly bodies. The first was discovered in 1864, at Tohirua, near Masterton, in the Wairarapa Valley, North Island, and is known as the Wairarapa meteorite; the second was found in 1879, at Makarewa, a small station near Invercargill, in Southland, South Island, and is known as the Makarewa meteorite; the third is the one included in this paper, and fell at Mokoia, in Taranaki, North Island, in 1908, and I have termed it the Mokoia meteorite.

The earliest instance of any meteoric phenomena being seen in New Zealand is one given me by an eye-witness—Mr. H. C. Field, of Wanganui—who states that it took place about the year 1853, but is not certain of the exact year. He describes it as follows: "I was standing outside my house at Waitotara, just after sunset, when I heard a loud whizzing noise overhead. On looking up I saw a brilliant body, apparently about the size of the moon, passing overhead in a S.S.E. direction, until it was lost behind some sandhills. A few days afterwards I saw by a paper that it was seen in Christchurch, and was supposed to have dropped into the sea S.E. of that town. While travelling across the sky it gave out a white-bluish light."

The next account that I have is from the Rev. P. W. Fairclough, who says in a letter to me, "I happen to know that a great aerolite passed over Wanganui about 1865, or between April, 1864, and March, 1867. It made a loud roaring noise, and seemed to travel towards Nelson, low down."

Mr. H. C. Field records another meteor that was seen from Wanganui, between 1864 and 1867, but travelling in an opposite direction to the former. Unfortunately, I cannot get the details from the newspapers, as the early records of the Wanganui *Chronicle*, in which a report was published, were some years ago destroyed by fire. It seems that at 2 o'clock in the morning Mrs. Field was up attending to a sick child, when she saw a sudden flash which made the room as bright as midday and quite eclipsed the light of the candle that she was carrying. A few seconds later a tremendous explosion was heard, sounding very much like the noise made by people

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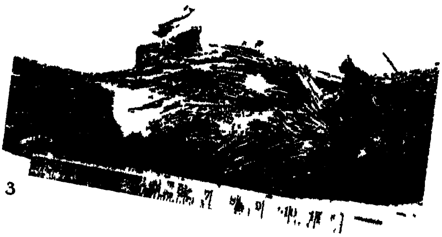
* Mr. G. R. Marriner died on the 25th February, 1910.—[Ed.]

PL XXIV



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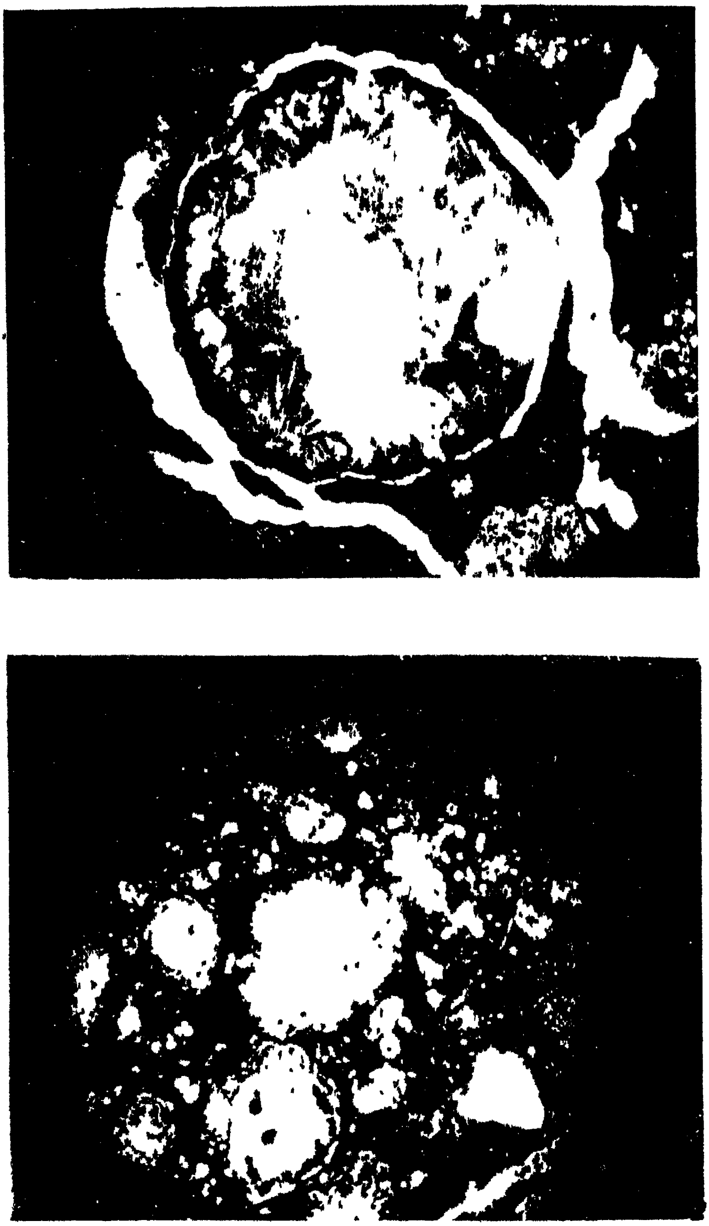
Face p 176

THE MOKOIA AEROLITE.—MARRINER



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THE MOKOIA AEROLITE.—MARRINER.

trying to imitate thunder by shaking a sheet of metal. Colonel Logan, who was stationed at Wanganui at the time, made all the sentries who were on duty that night report themselves to him next day. Mr. Field, who was acting-editor of one of the newspapers, was asked to be present. All the sentries except one stated that a very brilliant meteor came out of a thick bank of clouds off the mouth of the river and passed overhead northwards, and then exploded. The remaining sentry saw the meteor, but said that it travelled in an opposite direction.

THE WAIRARAPA METEORITE.

It was not till 1864 that the first specimen was discovered, by Mr. Richard Collins, at Tohirua, near Masterton, in the Wairarapa Valley, North Island.

In the *Geological Magazine* the following short account is published: "I have to thank Dr. Hector, F.R.S., Director of the Geological Survey of New Zealand, for a short account of the only meteorite which has yet been found in that colony, and which is preserved in the Colonial Museum at Wellington.* It is in the form of an irregular six-sided pyramid, 7 in. high and 6 in. across the base; the edges are rounded, and the sides slightly convex and indented with shallow pits. The capacity of the stone is 49 cubic inches; the weight, 480 oz.; and the specific gravity is 3·254; the hardness, 5–6. It is strongly magnetic, but exhibits no decided polarity. The surface is of a light rusty-brown colour, and is stained with exudations of iron chloride and sulphate. A freshly fractured surface is dark grey mottled with a bright metal-like particle of what may be iron-monosulphide. By treatment with copper-sulphate the presence of what may be iron in the form of metal was determined; with hydrochloric acid sulphuretted hydrogen was evolved, sulphur set free, and a large quantity of gelatinous silicic acid separated. The insoluble portion, consisting of silica and insoluble silicates, constituted 56 per cent. of the stone. In the soluble portion the predominating ingredients were iron (amounting to 24·01 per cent.) and magnesia, along with nickel, manganese, and soda; alumina and chromium are not present. These reactions so far indicate in the New Zealand meteorite the presence of olivine and an insoluble silicate, in addition to nickel iron and what may be triolite or magnetic pyrites."

There is also a similar account in the Juror's Report of the New Zealand Exhibition of 1865; it runs as follows: "An interesting form of iron exhibited was a rusty-looking mineral, weighing about half a pound, being a portion of a meteorite found in the Wairarapa Valley, in the Province of Wellington. It was not thought necessary to make a complete analysis of this mineral, but only sufficient to prove the similarity of its composition with that of other meteoric stones generally. The external surface of this mineral was of a rusty-red colour, in parts covered with exudations of chloride of iron, with a little sulphate. Freshly fractured, it showed a dark-grey colour, mottled over with bright metallic-looking particles (most probably protosulphide of iron). The shape of the mass is an irregular pyramid with rounded edges, measuring as follows: Height, 7 in.; length of base, 7 in.; breadth of base, 6 in.; contents, 49 cubic inches; weight, 9¼ lb. The surface was broken by rounded indentations never exceeding ½ in. in depth, evidently produced by weathering. No distinct cleavage was observed; hardness, 5 to 6; specific gravity, 3·251; moderately fusible in blowpipe-flame to a shining black magnetic slag with soda reactions. It was powerfully affected by the magnet, but did not exhibit any decided polarity. A little native iron was detected by the sulphate-of-copper test. Treated with warm HCl, a little sulphuretted hydrogen and sulphur were liberated, with a large quantity of silica in a gelatinous form. The total amount of insoluble matters after ignition was 56 per cent. of the original substance, consisting principally of liberated silica; the rest was undetermined silicates. Among the soluble matters, iron and magnesia predominated; there was a little soda, manganese, and nickel. Aluminium and chromium were tested, with negative results. The total quantity of iron present was 24·01 per cent. From the preceding facts it may be assumed that this mineral is a mixture of protosulphide of iron with iron chrysolite, with a small amount of insoluble silicates. The presence of native iron and nickel is almost conclusive of its meteoric origin." Mr. Donovan, of Wellington, is at present making a more complete analysis of this stone.

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* The stone was only deposited in the Museum. It is now in the possession of Mr. W. G. Mantell, of Wellington, to whom it belongs.

In 1868* Mr. E. Baker published an account of a brilliant meteor which was seen at Wellington. He says, "At about a quarter after 7 o'clock on the evening of the 5th August . . . I observed a light, very much brighter than the moon (which . . . was only two days old), shining brightly in a clear sky. The light appeared to be a large round ball of fire, about the size of the moon, travelling from an easterly direction towards the west. The ball of fire burst, and a portion of it apparently struck the ground at about fifty to a hundred yards from my house at Karori. There was a rumbling noise at the time of the descent of the meteor." Though mention is here made of a portion of the meteor falling to the earth, no stone seems to have been discovered.

In 1869† the Rev. A. Stock recorded a meteor which was seen at Wellington on the 8th November. He describes it in the following words: "It appeared suddenly in the E.S.E., at an altitude of 20°, and fell with a very rapid motion vertically. When it was first seen it appeared about three times as large as Venus, and shone with a yellow light. It suddenly appeared to diminish to a point of light, each diminution being accompanied with a shower of sparks, falling vertically. It suddenly increased to its old brilliancy, as suddenly diminished, then increased. Thus there were three brightnesses and two darker intervals. Another peculiarity was that it showed all the prismatic colours. There was no train of light left after its disappearance."

THE MAKAREWA METEORITE.

In 1879 the second stone was unearthed, this time at Makarewa, near Invercargill, in the South Island.

Professor Ulrich, F.G.S., writing on the find,‡ says, "The stone under notice was not seen to fall, but the following description regarding the site of its discovery, its mineral character, and structure can leave no doubt of its being of meteoric origin. Towards the end of the year 1886, when a large party of mining prospectors were preparing, with Government aid, for departure to the Big Bay district, west coast of Middle Island, Mr. Th.

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* Trans. N.Z. Inst., vol. i, p. 39.

† Trans. N.Z. Inst., vol. ii, p. 402.

‡ Proc. Roy. Soc., 1893, vol. liii, p. 54.

Fenton, a student of the Dunedin University School of Mines, was sent to Invercargill, where the party assembled, to instruct those of the men who desired it in rough assaying for gold and the use of the blowpipe. On the occasion of one of his lectures he received from a Mr. Arch. Marshall, for examination, a piece of stone which, from its weight and appearance, was supposed to be something out of the common. Mr. Fenton made a rough qualitative analysis of a sample of the stone, and on finding strong reactions for nickel thought it of sufficient interest to preserve the several small fragments remaining of the piece received from Marshall and to bring them with him to Dunedin, where he placed them at my free disposal. One of these fragments I devoted to the preparation of a number of thin sections sliced in different ways, and the microscopic examination of these convinced me at once of the meteoric character of the stone. After this I made every endeavour, by correspondence and ultimately travelling to Invercargill, to ascertain the exact locality where and under what circumstances the stone was found, and to obtain more of it if possible, for the surface outlines of the remaining fragments clearly indicated that it must originally have been of considerable size. The results of my investigations in these directions are the following: In the year 1879, at the completion of the connection of the railway-line Invercargill-Winton and the branch line Makariwa [Makarewa]-Riverton, two workmen, the brothers Arch. and I. Marshall, while engaged in removing a clay bank at Makariwa Junction, found in the clay, about 2½ ft. from the surface, a roundish stone which at once attracted their attention on account of its weight and because of the fact that in the clay-covered plain surrounding Makariwa Junction stones of any kind are a great rarity. They broke the stone with the pick, and, finding the inside of different aspect from the outside, took the fragments home, and, experimenting with them, discovered that they affected the magnetic needle. With the intention of having the stone some day further examined, the pieces were kept as curiosities; but, being unsightly, they were kicked from one corner of the room into another, and specimens were occasionally knocked off for friends interested in the find. Mr. Arch. Marshall, who gave me these particulars, told me, on further inquiry, that the stone when originally found had a knobby, roundish shape, was of the size of a large man's fist or perhaps a little larger, and might have weighed between 4 lb. and 5 lb. The exact place of the find was about half-way between the railway-station on the Winton line and the Stationmaster's house, some 20 ft. from the line of rails. A search by Mr. Marshall for another piece of the stone, which he thought was still somewhere about the premises at the time he gave the one to Mr. Fenton, proved, unfortunately, unsuccessful, and the only secured pieces of this meteorite are the two pieces sent with this paper and another small piece divided between the Dunedin and Wellington Museums. The specific gravity of the stone, determined from several small fragments, varied between 3·31 and 3·54; the variation is no doubt due to the unequal distribution of the metallic particles." A very thorough analysis of this stone was made by Mr. J. L. Fletcher, M.A., F.R.S., Keeper of Minerals in the British Museum.

In 1905 another meteor was seen and heard at Wanganui, and I am indebted to Mr. J. T. Ward, Director of the Wanganui Observatory, for the following description: "The meteor train of 1905, June, 10 days 5 hours 30 minutes: The streak only was seen by myself, but others heard the report also elsewhere. When first seen the track was plainly visible as a broad white band about 1·5° in width, on the western sky, in a straight line between the clouds; on looking a few moments later another portion of the band was seen, at an angle of about 90° to the first, bearing W. 65 ; alt., 30°. Business prevented my watching it for any length of time, but it remained visible for about twenty minutes or more."

The Mokoia Aerolite.*

This stone is by far the most interesting meteoric find yet discovered in New Zealand, and is unique in being the only one that was seen to fall.

Mr. J. L. Fletcher, of the British Museum, states that few aerolites are known that have not been seen to fall. He points out: "This may be due to the fact that a meteoric stone is less easily distinguished than is a meteoric iron, from ordinary terrestrial bodies, and will thus in most cases remain unnoticed unless its fall has been actually observed, while, further, a quick decomposition and disintegration must set in on exposure to atmospheric influences."

It was found at Mokoia, a small wayside station about fifty miles north of Wanganui, on the North Trunk Railway.

At 12.30 p.m. on Thursday, the 26th November, 1908, the people living near Mokoia were startled by a number of loud, sharp reports coming from the north, like rifle-shots, following very closely after one another. Those who were outside state that before they could recover themselves a white flash shot across the sky, leaving only a thin white cloud. Almost immediately several objects were seen to fall. One fell with a thud in a pine plantation (*Pinus insignis*) within an eighth of a mile from Mr. C. Hawken's homestead, and half a mile S.E. of the Mokoia Station. Mr. Hawken heard the whizzing sound and the report when the stone came in contact with the earth, being within an eighth of a mile from where it fell.

A ganger at a bridge over the Manawapou Stream states that another piece fell into some thick bush on the steep bank of the stream; and some time after a third portion was heard whizzing through the air like a rocket, and fell into the creek with a splash and hiss.

The Noise of the Fall.

Mr. C. M. Campbell, of Inaha, gives a very vivid description of what he heard. He says, "On the 26th November I was living on the East Road, ten miles about due east from Stratford, and I heard the reports very plainly. At first it sounded like a loud furnace-blast, and then, at intervals from three to five seconds, the report seemed like heavy rock-blasting, but there was a roar like heavy thunder during the whole time. From the first blast to the last would be fully twenty seconds."

Several men who were working on the railway-line heard two sharp explosions, resembling the crash of a number of horses galloping over a bridge, or like numerous rifles firing in a volley; while others say that it sounded like heavy iron tanks being rolled about on a lorry. This was almost immediately followed by a louder explosion, and then a hissing sound similar to that of a rocket travelling through air.

I was in Wanganui at the time, and I heard a sudden bang, which I put down to a very sudden and short earthquake-shock, and naturally I thought no more about it until I saw in the newspapers that it had been heard much louder in other towns.

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* Working on Mr. Fletcher's classification of meteoric stones, I have termed this one an aerolite.

The noise of the fall was heard for a distance of over a hundred miles in a direct line, along the west coast of the North Island, from Mount Egmont to the Rangitikei River, and as far back as Pipiriki.

Mr. Clemance, schoolmaster at Pipiriki, states that so loud was the noise there that a man who was working some distance from the settlement hurried back, thinking that a powder-magazine had blown up.

What was seen.

The day, though slightly cloudy at Wanganui, was clear and cloudless around Mokoia, but very little could be seen of the phenomenon, owing to the bright sunshine. At Mokoia itself only a think streak of a white film or vapour was seen for a few seconds after the fall.

Mr. E. Evans, of Waingongoro, writing to the Hawera *Star*, says that he observed the disturbance, which he says was caused by the passage of two meteorites through our atmosphere, and which travelled along parallel lines, from N.E. to S.W., leaving behind two streaks of smoke like railway-lines. The smoke was observable for quite fifteen minutes after the meteors had sped their way. With nearly a blue sky for a background, the sight was of great interest, but Mr. Evans thinks that if the event had occurred at night the brilliancy of the light as the balls flashed through the air would have been a never-to-be-forgotten spectacle.

Mr. Walter Hosken, of Bell Block, Taranaki, gives the following account of what he saw: "It may interest you to know that I witnessed it from the New Plymouth Racecourse. I was attending the Show, and at about half-past 12 I was standing talking to two young ladies, when one of them drew my attention to a curious object in the southern sky, and travelling in a westerly direction. At first sight I thought it was a kite, but found that I was mistaken when it burst and left a long tail of smoke behind, but we did not hear any report."

Mr. H. Chadwick states that his wife was also on the New Plymouth Racecourse, and saw a similar sight, but heard no sound, owing, no doubt, to the amount of traffic on the road at the time.

Mr. A. C. S. Tebbet, of Rangitikei, describes the sight as like a big shooting star, brighter than the sun, with a long tail.

The Alarm caused by the Noise.

The noise caused by the explosions and the mass rushing through the air not only alarmed the people in the vicinity, but caused a great stampede among stock. At Waingongoro the cattle and sheep were thoroughly startled, and ran huddling together. At Kakaramea horses and cattle were much scared, the former especially so, and were seen galloping about the paddocks. At Mokoia the effect was similar, and a man who was ploughing some distance from the station had all that he could do to keep his team from bolting.

What fell.

As nothing was known in Wanganui of the phenomenon except the noise, it was not taken much notice of, but on Sunday afternoon Mr. William Syme called on me at the Museum, and stated that a meteorite had fallen near Mokoia. In support of this statement he produced a small piece of rock of a dark colour, and said that it was obtained from the spot where the meteorite fell. My thanks are due to Mr. Syme for his promptness in letting me know of the fall, for the chances are that if he had failed to do so the stone would have been lost.

As the rock had all the appearance of a meteorite, I went to Mokoia by the first train on Monday morning Fortunately for Mokoia, it is only a small station, with a few houses, a church, and a creamery, or else a fair amount of damage might have been done by the meteorite. I went first to Mr. Hawken's homestead, where the meteorite had fallen. He kindly took me to a plantation which surrounded his house, and showed me where the ground had been struck. He himself had heard the whizzing sound, and also the noise made by impact with the earth; but he did not send the boy to investigate until some time afterwards, so that no evidence is forthcoming as to whether the stone was warm when it reached the earth.

The spot was not more than two hundred yards from the house, near which the owner's children were playing.

In its descent it snapped off a small branch of a fir-tree, and then struck a root that was growing on the surface of the ground. The stone hit the buttress about 29 in. away from the tree, but only struck it half on ; therefore it skidded off, after splintering the root somewhat, and buried itself in the earth. The hole was only 11 in. deep, 15 in. and 17 in. in diameter. In this cavity Mr. Hawken found the two lumps which are figured, and which are really the whole of the fragments that were found, with the exception of a few pieces which were found scattered around the hole to a distance of some yards. The lump A weighed 5 lb. 3 oz., and the lump B 5 lb. 2 oz. ; and both were presented to the Public Museum, Wanganui.

I cut off the root showing the splintered portions, and deposited it, with the portions of the meteorite, in the railway-station. Then, walking for a mile down the line, I came to the spot where the other portion was supposed to have fallen. This was on the high, steep banks of the Manawapou Stream, in which a third piece was said to fall. The banks are about 100 ft. or 200 ft. high, and are covered with a dense undergrowth and bush, into which one sank up to the waist at each step. As the day was a rainy one, and the bush sopping, it made travelling very slow, and after half an hour's scramble, during which I did not get very far, I was obliged to get back in order to catch the train, without having seen any signs of the other supposed piece of the aerolite.

The aerolite seems to have passed over Mokoia, as the descriptions given to me by eye-witnesses all agree that it was directly overhead. As it travelled across the sky, the numerous explosions evidently split some fragments off, and these fell at this spot, while the aerolite proper apparently went out to sea.

There seems to be some evidence to show that after passing Mokoia the force of the explosions broke the stone into two pieces, as two eye-witnesses say they distinctly saw two streaks of smoke behind the aerolite. This is supported by the fact that at Castlecliff (situated at the mouth of the Wanganui River) a portion at least was seen to fall into the sea with a loud report ; and a number of witnesses who were on the beach state that they saw a flash and the commotion caused by the mass falling into the sea, and they also heard the loud detonation.

Now, this place is about forty-two miles south of Mokoia, and, though the angle is too great for the stone to fall into the sea off the Wanganui

Heads, yet an explosion powerful enough to split the aerolite would easily give a portion of the stone a southern direction, so that it would fall near Wanganui.

The stone at Mokoia, in its fall, cut a branch of a fir-tree (*Pinus insignis*) in two at a height of 108 in. from the ground, and then fell on to a root that was growing on the surface of the ground and very much shattered it. When a perpendicular was dropped from the broken tip of the branch to the ground I found that the stone had travelled 46 in. due south from the time that it struck the branch. The branch was too small to alter its direction in any way.

By working from the above figures, I find that the fragments fell at an angle of 66° 56′ due south.

Analytical Report.

I am much indebted to Mr. B. C. Aston, Chief Chemist of the Department of Agriculture, who kindly analysed the stone for me. His report is as follows :—

"The fragment received for analysis consisted of fused globules interspersed in a black metallic oxide, while the centre of the piece contained nodules of a softer siliceous matter, white, grey, and purple in colour. The analysis below is probably only correct for the piece received, as the meteorite is evidently not homogeneous in character :—

Analysis.

	Per Cent.
Ferrous and ferric oxide (as Fe_2O_3)	36·95
Ferrous sulphide	5·64
Nickel-oxide	2·20
Manganese-oxide	Trace
Silica	37·55
Alumina	2·62
Lime (CaO)	3·50
Magnesium-oxide	6·30
Phosphoric anhydride (P_2O_5)	0·64
Soda	2·86
Cobalt-oxide	Trace
Graphite	1·25

The meteorite consists of the usual nickel iron generally found in meteorites (but in this case it has been completely oxidized), together with such siliceous minerals as augite and olivine."

Dr. C. Coleridge Farr, Canterbury College, who tested a fragment of the aerolite for its radio-active properties, says, "Your meteorite contains $0{\cdot}438 \times 10^{-12}$ gramme of radium per gramme of the meteorite. This is rather low value, judging from the radium contents of terrestrial rocks. The average of igneous rocks is about $1{\cdot}7 \times 10^{-12}$, or four times as great as the meteorite, and for sedimentary rocks about $1{\cdot}1 \times 10^{-12}$, or nearly three times as much."

Petrological Description of the Mokoia Aerolite.

Mr. R. Speight, M.A., B.Sc., Lecturer in Geology, Canterbury College, forwarded me the following report: "Macroscopically the stone is of a black-grey colour, with small rounded chondri of whitish appearance plainly visible. The determination of the specific gravity of a fragment gave a result 3·41, which is somewhat low; but this meteorite is remarkably vesicular, which makes is appear lighter than it really is. However, the graphite constituent points to the former existence of a hydrocarbon, and meteorites with hydrocarbons appear to be noted for their low specific gravity. Under the microscope it shows the following characters: It consists largely of a groundmass of dark unindividualised matter, which contains numerous irregular crystal fragments of small size, consisting chiefly of olivine, and occasional patches of brownish glass full of bubbles and black dust. In this base are numerous chondri up to 1·5 mm. in diameter, usually rounded and distinct from the groundmass, but at times ill-defined and grading into it. Some of the patches are cloudy and indefinite in character, but obviously of crystal particles. Many of the chondri show a nucleus of coarser grain, with a halo of smaller grains between it and the surrounding base. When enstatite is present they usually exhibit a fibrous structure. They are composed chiefly of olivine fragments, which are brecciated and irregular in shape, much fissured by cracks, clear as a rule, and containing rounded black grains and bubbles, apparently of gas. The size of the fragments is tolerably uniform in each chondrus, with the exception of those showing the halo, and they grade downward from 1 mm. in length to those which can only be separated by higher powers of the microscope. Augite and also enstatite are present, some of the chondri being composed exclusively of the latter mineral arranged in sheaf-like aggregates, but it occurs frequently associated with olivine in the same chondrus. Small fragments of feldspars are occasionally seen with fine twinning of the albite type. The only means of determination that could be employed was Michel-Levy's method, and from the small number and size of the fragments even this was not altogether satisfactory. There were several small extinction-angles, but they ranged as high as 27°, corresponding to an acid labradorite. Anorthite appears to be the common feldspar of meteorites, though others have been observed occasionally. The chemical analysis shows that the rock contains no potash, but 2·86 per cent. of soda, and this may have come from soda-bearing feldspar, as none of the other minerals present are usually alkaline. Some of the chondri contain a small quantity of glass, occasionally as a kind of nucleus, and in one case it has apparently corroded the olivine crystal where it has been in contact with it. This is the only evidence which I have been able to find which points to a high temperature preceding the final consolidation of the meteorite. The phenomenon is an isolated one, and the brecciated structure of the chondri with their interior of larger fragments surrounded by a row of smaller ones, as well as absence of melting on the edge of the fragments, distinctly suggests that this has not been the case, or, if it has been, the rock has cooled very quickly. I was unable to detect with certainty in the specimen at my disposal any of the sulphides or native elements usually occurring in meteorites, and no doubt it belongs to that class usually designated as 'stony.'"

Dr. P. Marshall, Professor of Geology, Otago University, Dunedin, to whom I gave a fragment of the stone, sent me the following remarks: "As you anticipated, it proved a very difficult matter to make a section of the piece of the meteorite that you gave me. However, I send you the result. The clear crystals are olivine, and the spherules are, I fancy, formed of radiating crystals of the same mineral. There is a very little native iron. By far the greater portion appears to be magnetite. The magnet will lift quite large pieces of the meteorite, and the mineral is perfectly opaque, so I have little doubt as to its nature."

In conclusion, I should like to express my indebtedness to all those who have so willingly assisted me, especially Mr. C. Hawken, Mokoia; Mr. J. L. Fletcher, British Museum, London; Mr. A. Hamilton, Wellington; Mr. J. T. Ward, Wanganui; Mr. R. Speight, M.A., Christchurch; Dr. P. Marshall, Dunedin; Mr. B. C. Aston, Wellington; and Mr. W. Syme, Wanganui.

EXPLANATION OF PLATES XXIV AND XXV.

PLATE XXIV.

Fig. 1. Fragment A of Mokoia meteorite; ⅓ of natural size. Weight, 5 lb. 3 oz.
Fig. 2. Fragment B of Mokoia meteorite; ⅓ of natural size. Weight, 5 lb. 2 oz.
Fig. 3. Portion of the root of fir-tree (*Pinus insignis*), showing where it was struck by a portion of the meteorite.

PLATE XXV.

Fig. 1. General structure of meteorite, showing chondri in base. × 15
Fig. 2. Chondrus composed of olivine and enstatite separated by a circular crack from the surrounding base. × 36.

ART. XV.—*On the Radio-activity of the Artesian-water System of Christchurch, New Zealand, and the Evidence of its Effect on Fish-life.*

By C. COLERIDGE FARR, D.Sc., &c., and D. C. H. FLORANCE, M.A., M.Sc.

[*Read before the Philosophical Institute of Canterbury, 13th July, 1909.*]

SOME time ago a committee was set up by the Philosophical Institute of Canterbury to examine the various problems suggested by the artesian system of Christchurch; and, though the committee is in no way responsible for the opinions which will be expressed, and, indeed, may not agree with them, yet this paper may be regarded as a first result of its labours, as it fell to the authors to examine the water with regard to its radio-active condition, whilst others are undertaking other investigations.

The method of examining the water for radio-activity was that adopted by others, notably by Strutt. The water was collected in a flask holding approximately half a litre. This was immediately corked, with a piece of glass tube passing through the cork, on the outer end of which was a short piece of rubber tubing which was closed by a pinch-cock. The same time (twenty minutes) was allowed to elapse between the collection of each sample of water and the commencement of operations for its testing. To test the gas the indiarubber tube was connected to a Liebig condenser, and the water boiled so as to drive off the gases contained in the water. These, together with the air left in the top of the flask, which was never quite filled with water, were collected over water, and, to insure their all passing over into the collecting-vessel, at the close of the boiling the condensing-water was stopped, and steam was sent through the apparatus. The boiling was continued for half an hour. After another interval (the same for all the waters tested, ten minutes) the gases so collected were passed on into an airtight electroscope which had previously been exhausted to about half an atmosphere. The partial vacuum so formed was never filled to atmospheric pressure by the gases collected from the water, as the volume of these was never sufficient. To make up for this deficiency, the necessary amount of air was allowed to pass through the whole apparatus to the electroscope, which acted as a further safeguard against any radio-active gas remaining in the tubes. Between the collecting-vessel and the electroscope two drying-tubes (the first containing calcium-chloride, and the second sulphuric acid) were placed. Previous experience had shown that these were sufficient to thoroughly dry the gas if (as was the case) it was passed so slowly through them that ten minutes was taken over the operation. The electroscope was charged to a potential of 220 volts, and the rate of motion of the leaf was examined by a reading-microscope with a micrometer eyepiece. The electroscope was standardised by performing the same experiment with a standard solution of radium, kindly given to us by Professor Rutherford. The solution used contained $3{\cdot}925 \times 10^{-10}$ grammes of radium, and before boiling was allowed to stand securely corked for at least three weeks, so that the equilibrium amount of radium emanation might be generated.

Results.—All the wells examined were found to contain radium emanation, though in none of them could any radium in solution be detected. For the standard solution of radium with the equilibrium amount of emanation the rate of leak of the electroscope was 64 micrometer-divisions per minute. The leaks per litre of the various wells examined were as follows:—

Well.	Depth in Feet.	"Leak" per Minute.
Museum	262	197·0
Boys' High School	290	209·0
Ward's brewery	420	199·7
West Christchurch School	490	144·6
Wharenui	406	163·0
Holly Lea	451	185·8
Waltham School	326	223·6
New well (Aikman's Road)	268	164·0
New well (Chemical Laboratory)	60–70	130·0
No. 1 well (Gardens)	65–75	113·0
No. 2 well „	65–75	135·5
No. 3 well „	65–75	143·0
Well-supply to aquarium in Exhibition	..	153·0
Dr. Moorhouse's well	238	152·0
San Marola Well, Papanui Road	..	127·0
Exhibition well	423	154·0
River Avon	..	27·0

Whilst these figures indicate that there is a considerable amount of radium emanation in the water of all the wells tested, they do not apparently show that there is any simple relation between the amount contained and the depth; it is possible that some of the depths given may be wrong, though there is reason to believe that the distribution of the water-bearing strata is very irregular as regards depth. Thus we think, from consideration of nearness and radio-activity, it might be inferred that the same stratum supplied both the Museum and the Boys' High School, whilst from the depths alone this inference might not be drawn. The conclusion might also be drawn that the water supplying Dr. Moorhouse's well does not pass through similar materials. For reasons to be subsequently explained, the wells in the Fish-hatchery Gardens of the Acclimatisation Society have been those most examined, and all these, together with a well of about the same depth at the new Chemical Laboratory building, give approximately the same radium-emanation content. On several of the wells—notably those of the Acclimatisation Society's Gardens—tests have been made several times of the radio-activity of the water; and the results show that over the period of these experiments (some two months) the amount of radium emanation per litre is approximately constant for the wells so tested. It is certain that the radio-active gas was radium emanation, for on several occasions the gases boiled off from a sample of water were left in the electroscope for four or five days, when the curve of decay followed closely that obtained from the gas boiled off from the radium-solution, and also the well-known radium-emanation curve. As a general rule, however, the rate of motion of the electroscope-leaf was determined as soon as the gas was in the electroscope—that is, one hour after the commencement of boiling. The leaks given are these, and not the maximum leak, which would occur about three hours later and would be about 25 per cent. more.

A comparison of the radio-activity of our springs with that of others is of interest. Curie and Laborde have examined the waters of certain mineral springs in France (Comptes Rendus, vol. cxlii, p. 1464). The radio-activity of these springs, expressed in our units, is as follows:—

Plombiers { Source Vauquelin	376
Plombiers { Tron des Capucins	787
Aix-les-Bains, No. 1	461
„ No. 2	257
Bourbon-Lancy, Source Le Lymbe	169
Contrexeville, Source de Pavillon	85
La Roche Posay	85

M. Repin (C.R., vol. cxlvii, p. 388) has given particulars of three other waters of special interest, whose values, expressed in the same units, are.—

Source de Villard Clement, No. 1	50
„ „ No. 2	18
Source de St. Pancrece	27

The first series are well-known mineral springs which are rich in dissolved salts, and which might therefore be expected to contain a considerable amount of radium emanation. From these it will be seen that the waters of Christchurch contain an amount of radio-active gas comparable with that of well-known springs in Europe, and more than the amount in quite a number of these springs.

Seeing, therefore, that the Christchurch water contains radium emanation, and that this gas has properties of a remarkable and energetic character, it occurred to us to endeavour to ascertain whether any, and, if so, what, effects on animal life could possibly be ascribed to it. As fish were more likely to show its consequences than any other form of life, inquiries were set on foot relative to those inhabiting the streams and ponds supplied by the artesian system. Surprising results (to us, at any rate) were soon forthcoming. It appears that a disease amongst young trout in the yolk-sac stage, called blue swelling, was until a few years ago common in the hatchery at Christchurch, when it was to a large extent eliminated by removing the newly hatched fry from the immediate neighbourhood of the well, and allowing the water to trickle over obstacles before reaching the boxes containing the fish. Various authorities informed us that more developed fish, if confined near a well, died within a few days; Mr. Johnston, whose name has been so closely connected with the introduction of trout into New Zealand, using the expression that water direct from a well was a deadly poison to them.

With a knowledge of these facts we decided to make some experiments to ascertain how far, if at all, the results were attributable to radium emanation; and for cordial assistance in this, as well as for supplying us with a large number of ova and also some fry for experimental purposes, our hearty thanks are due to the Council of the Canterbury Acclimatisation Society as a body, and particularly to Dr. Moorhouse and to Mr. Sloman. Our special thanks are due to Mr. Charles Rides, of the Fish-hatchery, to whom the experiments have given much additional work.

We first tested the alleged fatal results upon fish of water directly taken from a well, and, with the object of seeing the effect of radium emanation, we chose the well at the Museum, which, besides being conveniently situated, was particularly rich in radium emanation. On Tuesday afternoon, the 1st June, 1909, seven healthy yearling fry were placed in the sand-box of this well, whose radio-active content, expressed in our units, is 197. When this box is running over, the water is supplied to it at the rate of 3·4 litres per second, and this was its condition throughout the experiment. On the following Friday morning one of these fish was found dead in the box, on the Saturday morning two more had died, and on the Sunday two more, one of which, however, was found in the overflow-pipe, and might possibly have got there and been killed. Two survived until the following Tuesday, when they were removed alive and apparently well. Thus, neglecting the one in the overflow, 66 per cent. had died in five days. The radium-emanation content of the water from which the fish were obtained, and where they had been living for nearly a year, was found to be 80.

As it was felt that the environment of these fish was far from comfortable, and to eliminate any poisoning action due to a little old red-lead clinging to the sides of the sand-box which it was thought possible the fish might have eaten, a further batch of eighteen fish was obtained, of the same age as the last, and from the same pond. These were distributed in two lots, eight being put in the sand-box of radium-emanation strength 197, and ten in a considerably larger concrete tank, into which water from the sand-box overflows. In this tank water-weeds of various kinds are growing, though not in any great quantity, its radium-emanation value being 171. These boxes we call No. 1 (sand-box) and No. 2 (larger tank). The fish were placed in these boxes on Wednesday, the 9th June, at 4.30 p.m. On Monday, the 14th June, one was found dead in No. 2; on the 15th June four were found dead in No. 1 and two in No. 2; whilst on the next day, the 16th June, one fish was found dead in each box. Thus in six days six out of eight had died in No. 1, and four out of ten in No. 2. These facts (taken in conjunction with the experience of others) prove that the water of some wells is, if taken near the source, certainly deadly to a large proportion of the fish. Whilst this is so, it is also indisputable that fish live quite comfortably if the water be allowed to run along an open channel from the well to the pond; and this is also true of the well upon which these experiments have been made, for the same water trickles on to a further tank in which goldfish are kept quite successfully.

Character of the Water.—As far as dissolved salts are concerned, the artesian water of Christchurch is remarkably pure, being used for many chemical purposes for which distilled water is usually necessary. Indeed, it has been quoted as an example of what an ideal water should be; but its character in this respect has no bearing on the question, as the cause of the effects under consideration rapidly escapes. In another paper* we deal with the gases dissolved, and with the way these gases are altered by rippling over obstacles. Messrs. Marsh and Goreham have (Report, Bureau of Fisheries, 1904, Washington, p. 345 *et seq.*) ascribed what appear to be somewhat similar results to an excess of dissolved gas, particularly nitrogen, and say that 2 cubic centimetres of gas per litre in excess of the saturation amount will cause symptoms, whilst a somewhat larger amount may be fatal. At present, however, we are concerned with the evidence in favour of radium emanation being a possible cause, as this was not considered by them.

We therefore made experiments to ascertain how rapidly the radium emanation escaped as the water fell over obstacles. Tank No. 1 has already been stated to have a value 197. In the very short distance from No. 1 to No. 2 the radium-emanation number fell away to 171, whilst the tank in which the goldfish live, and to which a very small trickle goes, gives a leak per litre per minute of 30. It thus appears that the emanation escapes rapidly; but, to test it further, some water from another well giving a value of 127 was poured three times from one glass to another, whereby the value became reduced to 39.

By the courtesy of the authorities of the Acclimatisation Society we have had facilities for observing the behaviour of 75,000 healthy wild brown-trout ova as they developed from the eyed state until they hatched, and of ascertaining how the mortality amongst them varied with distance from the well. For this purpose they were distributed in two parallel rows of five boxes in a row, each box containing 7,500 eggs. The water trickled down these two rows from box to box, falling from one box to the next over a fall of about 8 in. By this means the water, after supplying the eggs in one box, was re-aerated before it went into the next. It was known that there was a much heavier loss of eggs in the boxes the nearer these were to the well—so much so that the use of the top pair of boxes (one box in each row) had been discontinued owing to the great loss in them in the egg stage, and also to the greater development of "blue swelling" in the yolk-sac stage. The number of eggs taken dead out of the various boxes was counted for us by Mr. Rides whilst we made a determination of the radium-emanation content per litre and also (*loc. cit.*) of the gas content. In the following results the dead eggs in any corresponding pair of boxes are added together, and they are therefore the deaths in 15,000 eggs:—

	Dead Eggs before Hatching.	Radium Emanation.
First pair of boxes	6,675	126
Second ,, ...	5,232	111
Third ,, ...	4,650	95
Fourth ,, ...	4,713	83
Fifth ,, ...	3,252	69

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* "On the Influence of Ripples on the Gas Content of the Artesian Waters of Christchurch." (See p. 237 of this volume.)

The radium-emanation content of the water taken actually from the well-pipe was in this case 135·5. These numbers show very conclusively how marked is the diminution of mortality with recession from the well; and, put another way, there is a strong correspondence between the number of dead eggs and the radium emanation. Thus, taking on the one hand the number of dead eggs in the top box as 100 x (x, of course, then equals 66·7) and the radium-emanation content of the top box as 100 y (then y is 1·26), we have the following correspondences:—

	Percentage of Dead Eggs.	Radium Emanation.
First pair of boxes	100 x	100 y
Second ,, ...	79 x	88 y
Third ,, ...	69 x	75 y
Fourth ,, ...	70 x	66 y
Fifth ,, ...	48 x	55 y

It is only right to add that these figures do not represent in any way the present practice at the hatchery. It was known that the mortality would be high, though the cause was not known; and it was to ascertain the cause that so large a number of eggs were sacrificed.

The figures with regard to blue swelling as it subsequently developed in these boxes, and to gas content, are given in the paper dealing with the dissolved gases (*loc. cit.*); but, even if death in maturer fish can be ascribed to an excess of gas, which to us does not yet appear to be certain, it is difficult to apply the theory of Marsh and Goreham to the mortality in eggs or to blue swelling.

ART. XVI.—*On an Isopod inhabiting Ants' Nests in New Zealand.*

By CHARLES CHILTON, M.A., D.Sc., F.L.S.

[*Read before the Philosophical Institute of Canterbury, 3rd November, 1909.*]

IT has long been known that an isopod, *Platyarthrus hoffmannseggii*, Brandt, is found associated with several species of ants in England and Europe. It has been described by Bate and Westwood,* Schoebl,† Webb and Sillem,‡ and others. Lord Avebury§ has also published the result of his observations and experiments upon it, and has suggested that it acts as a scavenger in the ants' nest.

When I was preparing my paper on the terrestrial *Isopoda* of New Zealand‖ in 1900, I heard from Mr. W. W. Smith that he had found two specimens of an isopod supposed to belong to the genus *Platyarthrus* in ants' nests in New Zealand, and that these had been forwarded along with the ants to specialists in Europe. My efforts to trace these specimens were unsuccessful, and at that time I could merely note their occurrence in ants' nests. In 1902 Mr. J. MacMahon sent me numerous specimens of an isopod found in association with the nests of ants in the Rai Valley, in Marlborough, and later on Mr. Smith sent me similar specimens from New Plymouth. Although these specimens were undoubtedly associated with the ants, it was not quite certain that they were habitual guests in the nests, and I therefore waited for further evidence. Recently, however, Mr. Smith has found other specimens undoubtedly living in the ants' nests,* and associated with two species of ants—viz., *Amblyopone cephalotes*, Smith, and *Huberia striata*, Smith; and I am therefore now able to describe the isopod. It proves to belong not to *Platyarthrus*, but to *Trichoniscus*; it thus belongs to a different family of terrestrial isopods, and it is interesting to note that we have here the same habit of life arising independently in two quite different isopods. It is rather larger than *Platyarthrus hoffmannseggii*, being about 5 mm. in length, and, though very much lighter in colour than the ordinary terrestrial *Isopoda*, it is not quite white, but is generally marked with bands or patches of pale brown on a white ground. Moreover, it is not blind, but possesses fairly perfect eyes, provided with, apparently, the normal amount of pigment. The description of the species is given below.

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* "British Sessile-eyed Crustacea," II, p. 464.

† Sitzungsb. d. k. Akad. d. W. math. naturw. Cl. xl Bd., No. 9, 1860, p. 279.

‡ "The British Woodlice," 1906, p. 30.

§ "Ants, Bees, and Wasps," 16th edition, 1902, pp. 75, 90, and 407.

‖ Trans. Linn. Soc., 2nd ser., Zool., vol. viii, p. 100.

Trichoniscus commensalis, sp. nov.

Body rather broadly oval, fairly convex, pleon not abruptly narrower than the peræon; whole dorsal surface thickly covered with spiny tubercles, which are arranged more or less regularly in transverse rows—viz., one row along the posterior margin of each segment, and two or three much more irregular rows on the anterior part of each segment. In the pleon there is a fairly well-marked row along the posterior margin of the third segment, the other portions of the dorsal surface of the pleon usually bearing only minute spines.

First segment of peræon the longest, and produced into two rounded lobes reaching as far as the eyes; the last segment of the peræon with the postero-lateral angles produced so as to include the first three segments of the pleon, and to reach almost to the end of the epimera of the 3rd segment; in the pleon the 3rd, 4th, and 5th segments bear fairly well-developed epimeral portions. Terminal segment with the sides concave, the angles rounded, posterior margin straight or very slightly convex and bearing four small spines.

Eyes fairly well pigmented, formed of three ocelli, fairly close together.

Antennæ stout, especially the penultimate segment of the peduncle, which is half as broad as long, the last segment longer than the preceding, and bearing fine setæ on the outer side and roughened tubercles on the inner; the flagellum as long as the last segment of the peduncle, composed of five joints, the last bearing a pencil of fine hairs. The uropoda fairly stout, outer branch stouter but not much longer than the inner, both covered with fine setæ and bearing a tuft of longer setæ at the extremity. In the last pair of legs the ischium is produced on the outer side into a prominent triangular process or plate bearing one or two stout setæ.

Colour white with pale-brown markings, usually more or less arranged in longitudinal lines; the colour, however, varies very considerably, some specimens having the dorsal surface almost wholly covered with brown markings.

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* Mr. Smith says that on one occasion "the ants were in the act of carrying off the specimens when I took them from them."

Length, 5 mm.; breadth, 2 mm.

Hab.—New Plymouth and Mount Egmont, in nests of *Amblyopone cephalotes* and *Huberia striata* (W. W. Smith); Rai Valley, in nests of ants (J. MacMahon). Probably widely distributed in the North Island and in the north-western portion of the South Island.

The specimens from Greymouth collected by Mr. R. Helms, which I had previously referred with hesitation to *T. otakensis*,* belong to the present species. I have specimens also from Swanson, Auckland (H. Suter), and one from Kapiti Island (E. A. Newson). The last specimen is much browner than those actually taken in ants' nests by Mr. Smith and Mr. MacMahon, and it is possible that it was not living in association with ants. There is the same doubt with regard to the Greymouth and Auckland specimens.

Art. XVII.—*The Cam-lever Balance.*

By J. Clement Cuff.

[Read before the Auckland Institute, 22nd November, 1909.]

"Cam-lever balance" is the name given by the author to a modification of the bent-lever balance whereby the scale becomes regular throughout its whole length.

The bent-lever balance is more convenient in use than any other form of gravity balance because it indicates the weight by direct observation without having to slide a counterpoise, or shift the fulcrum, or put counterbalancing weights in a scale-pan. A spring balance also has these advantages, but a spring is not so reliable and constant as gravity. On the score of simplicity of construction and delicacy of action a bent-lever balance is better than a spring balance. The one great defect of the bent-lever balance is the irregularity of its scale; therefore this paper is written to explain clearly how this solitary defect of this otherwise excellent form of balance can be remedied in a very simple way.

In the bent-lever balance the counterpoise arm is actually much longer than the scale-pan arm, and these lengths are constant, but the virtual lengths of the two arms change with every change of weight in the scale-pan. The virtual length of the arm is the horizontal distance between the fulcrum and a line drawn vertical to the centre of gravity of the arm and its attached or suspended weight. If the angle of deflection of the long arm from the vertical be called A, then the virtual length of the long arm will vary as the sine of A, and the virtual length of the short arm will vary as the cosine of A, exactly if the effective directions of the two arms are at right angles, otherwise approximately. This relationship gives a scale increasingly compressed in the direction of the higher readings.

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* Trans. Linn. Soc., 2nd ser., Zool., vol. viii, p. 117.

This great defect is entirely removed by applying to the scale-pan arm a correctly shaped cam, which prevents the too rapid shortening of the virtual length of the scale-pan arm for any given increase in the deflection of the counterpoise arm. The scale-pan is suspended by a tape or cord which passes over the curved surface of the cam and is attached to it on its farthest side.

With any gravity balance the condition of equilibrium is attained when the product of the length (or the virtual length) of the arm multiplied by the weight on one side of the fulcrum is equal to the product of the length (or the virtual length) of the arm multiplied by the weight on the other side of the fulcrum. The product of the said factors on either side of the fulcrum is called the "moment of force" on that side.

As an example: Let the length of the counterpoise arm be 140 mm., and the limit of weight to be measured by the balance (including the weight of the scale-pan) be 45 oz., at a distance of 20 mm. from the fulcrum; then the moment of force on the scale-pan arm would be 45 × 20 = 900, and the counterpoise weight must be 900 divided by 140 (the length of its arm), or 6·4286 oz., or very nearly 6·43 oz. (See fig. 1.)

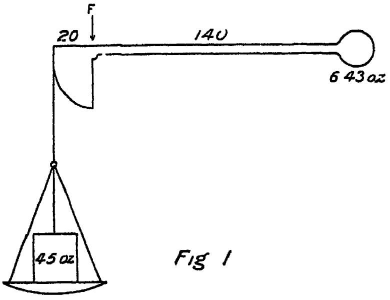


Fig 1

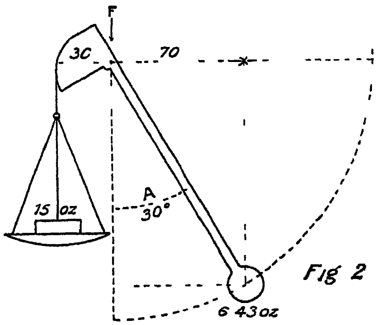


Fig 2

It is required that when the weight suspended at the end of the scale-pan arm be reduced to any given proportion—say, one-third of the maximum—then the counterpoise arm should rest in equilibrium at the same proportion of its total range—that is, at one-third of 90° (or 30°) from the vertical. In this position (see Fig. 2) it is seen that although the actual length of the counterpoise arm has remained the same, yet its virtual length for reckoning its balancing-power has been reduced to one-half, or 70 mm., and the moment of force on its side of the fulcrum has been reduced from 900 to 700 × 6·4286 = 450. Then, the length (or the virtual length) of the scale-pan arm must be 450 divided by one-third of the maximum weight—that is, one-third of 45 oz. (or 15 oz.). This gives 30 mm. as the required length of the scale-pan arm in this position, instead of 20 mm. as in the first position.

To make the scale regular, the scale-pan has to be suspended at a different distance from the fulcrum for every different angle of deflection of the counterpoise arm.

Let A = the angle of deflection of the counterpoise arm from the vertical, and L = the actual length of the counterpoise arm, which agrees with its effective length only in its horizontal position, or when A = 90°: then L × sin A = the virtual length of the counterpoise arm for any angle A. Let C = the weight of the counterpoise: then L × sin A × C = moment of force on the counterpoise side for any angle A. Let W = the weight on the scale-pan side: then $\frac{L \times \sin A \times C}{W}$ = the required distance from the fulcrum at which the scale-pan must be suspended for any given angle A. Because the angle A must be in proportion to W, let W = nA: then $\frac{L \times \sin A \times C}{nA} = \frac{\sin A}{A} \times \frac{LC}{n}$ = the required distance from the fulcrum at which the scale-pan must be suspended for any given angle A. Hence it is evident that in a gravity lever balance, in order to make the angle of deflection (A) of the long arm proportional to the weight suspended from the short arm throughout the whole length of the quadrant, whilst the virtual length of the long arm varies as sin A, the virtual length of the short arm must vary as sin A / A.

The above relation is fixed for all balances of this class, but L, C, and n may have any values according to the desired dimensions of the balance. In the example given they are 140, 6·4286, and $\frac{1}{2}$ respectively. The value of n is $\frac{1}{2}$ because the number of ounces to be indicated by any angle of deflection happens to be one-half of the number of degrees in the angle. In this or in any other case n will equal 90 divided by the total number of units of weight (including the weight of the scale-pan) intended to be the full range of the balance.

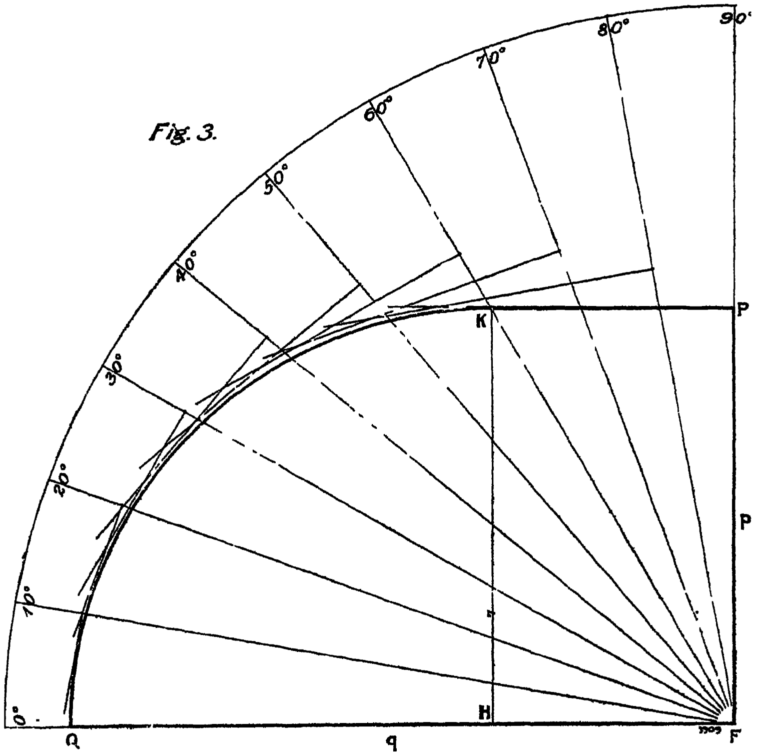
In the following table, column (1) gives A. the angle of deflection from the vertical of the long arm, in degrees. Column (2) gives sin A. The virtual length of the long arm varies with the angle A as the figures in this column. Column (3) gives sin A / A. The virtual length of the short arm, with the angle A, must vary as the figures in this column. Column (4) shows the application of column (3) to the particular example given, in which LC/n is equal to 1800. It gives, in millimetres, the various distances from the fulcrum at which the scale-pan must be suspended according to the angle A given in each case.

A. Degrees. (1.)	Sine of A (2.)	$\frac{\text{Sine A}}{\text{A}}$ (3.)	(4.)
1	0·01745	0·01745	31·41
5	0·0872	0·01743	31·37
10	0·1736	0·01736	31·30
20	0·3420	0·01710	30·80
30	0·5000	0·01667	30·00
40	0·6428	0·01607	29·00
50	0·7660	0·01532	27·50
60	0·8660	0·01443	26·00
70	0·9397	0·01342	24·00
80	0·9848	0·01231	22·20
90	1·0000	0·01111	20·00

From the figures in column (3) a curve can be plotted which will give correctly the shape of the required cam (see fig. 3).

Taking the point F, which represents the fulcrum of the balance, as centre, describe the quadrant marked F, 0°, 90°. Draw eight intermediate radii, all at equal distances of 10 degrees, and number them accordingly. On each radius numbered as in column (1) of table, mark off the length indicated in column (3) according to any convenient scale of units. For instance, on the radius for 10 degrees mark off 173·6 mm., on the radius for 20 degrees mark off 171 mm., and so on up to 90 degrees, 111·1 mm. At the point so marked in each radius erect a perpendicular inclining towards the side of lower magnitudes. These perpendiculars will intersect at several points. Draw a curve tangential to these perpendiculars on the inner side. This is the true curve required for the cam. The distance to be marked off on the radius F to 0° is very approximately the same as that given in the table for 1 degree—namely, 174·5 mm.—and this point marks the lower termination of the curve.

Fig. 3.



An examination of the true cam-curve reveals that a very close approximation thereto can be made in a much more simple way (see fig. 3). Call the distance F to P, on the vertical side of the quadrant, *p*: and the distance F to Q, on the horizontal side, *q*: then the ratio of *p* to *q* must always be as $\sin 90^\circ / 90^\circ$ to $\sin \doteq 0^\circ / \doteq 0^\circ$. Taking 1 minute of arc, or $\frac{1}{60}$ degree, as being $\doteq 0^\circ$, then *p* is to *q* as $0{\cdot}0\dot{1}$ is to 0·0174505098. These figures are almost perfectly in the ratio of 7 to 11. If *p* equal 7 units of length and *q* equal 11 of the same units of length, then *q* will be $0{\cdot}05\dot{6}\dot{3}$ per cent. too long, or less than one part in 1776 too long.

Hence the simple and practical way to mark off the cam-curve, approximately, is as follows: (1) Draw two lines, FP and FQ, at right angles; (2) make the vertical line FP equal to 7 units of length, of any suitable size; (3) make the horizontal line FQ equal to 11 of the same units; (4) mark a point H on FQ so that the distance from Q to H equals FP;

(5) using H as centre, describe a quadrant HK of radius HQ; (6) join K to P by a straight line. thus completing the cam-contour.

This simple curve falls slightly within the true cam curve for a portion of its length, but so slightly as to cause a maximum error of only about 1 per cent. in the virtual length of the short arm of the balance. In the example given this amounts to less than ⅓ mm. This makes no difference to the perfect accuracy of the balance; it only makes a slight difference in the perfect equality of the distances between some marks on the scale.

All need of levelling the balance when it is stood upon any nearly level surface can be avoided by suspending the scale so that it can itself assume the correct position by the action of gravity.

A very simple and effective anti-parallax sight is fixed to the pointer. This consists of a needle having an enlarged eye, through which the observer must look at the pointer, and thus note the point it indicates on the scale.

The cam lever, the swivelled scale, and the anti-parallax sight combine to produce a balance of surpassing excellence for accuracy and speed of measurement. This invention the author presents to the society in the hope that some one will be sufficiently enterprising to put it upon the market, to the great advantage of himself and the public at large.

Art. XVIII.—*Description of a New Native Grass* (Poa).

By D. Petrie, M.A.

[*Read before the Auckland Institute, 22nd November, 1909.*]

Poa oraria, sp. nov.

Gramen cæspitosum, parce foliosum, 40–50 cm. altum, leve, politum, perenne.

Culmi multi, erecti, glaberrimi, graciles, a basi ramosi, teretes, 2-nodosi, internodiis elongatis, folia longitudine æquantes, foliorum vaginis pæne ad imam paniculæ partem vestiti.

Folia longe vaginantia, vaginæ inferiores latæ, membranaceæ, stramineæ, leviter striatæ; ligula vaginam latitudine æquans, oblonga, obtusa; lamina teres, erecta, involuta, subrigida, gracillima, leviter striata, apice subacicularis.

Panicula strictissima, linearis, ± 10 cm. longa; ramis 3 v. paucioribus, brevibus, teretibus, glaberrimis, paucas spiculas sublonge pedicellatas gerentibus.

Spiculæ anguste oblongæ v. plus minus cuneatæ, 8 mm. longæ, 3 mm. latæ, 4 v. 5 flosculos gerentes.

Glumæ vacuæ subæquales, spiculis tertia parte breviores, anguste lineari-lanceolatæ, acuminatæ, 3-nervatæ.

Glumæ floriferæ anguste lanceolatæ, acuminatæ, membranaceæ, plerumque 5-nervatæ, nervo medio solo ad apicem attinente, basi parvo pilorum brevium flocco prædita, in nervis subsericeæ, alibi plus minus scabridæ.

Palea gluma florigera paulo brevior, 2-nervata, nervis delicatule ciliatis.

Hab.—Moist and wet stations at the head of several of the sounds of western Otago (Deep Cove, &c.). Collected by Mr. B. C. Aston in mid-January, 1909; it appears to flower towards the end of December.

ART. XIX.—*On* Poa breviglumis, *Hook. f.*

By D. PETRIE, M.A.

[*Read before the Auckland Institute, 22nd November,* 1909.]

THE writer has long entertained a suspicion that the native grass *Poa breviglumis*, Hook. f., was not really distinct from what is taken to be the *Poa imbecilla* of Forster. Hooker's species was originally published in the "Flora Antarctica," vol. i, pp. 101 and 102 (1844), and was founded on specimens collected on Campbell Island. The name *Poa imbecilla* was applied by Forster in 1786 to a New Zealand grass, but he published no diagnosis or description of it. A number of years later Forster's name was assigned by Allan Cunningham, in his "Prodromus" (1836), to the *Poa* now so named.

In the "Flora Novæ-Zelandiæ" (1853) Hooker includes and describes Forster's *Poa imbecilla*, accepting Cunningham's identification of the plant, but he does not in any way refer to its likeness to his own *Poa breviglumis*. This may have been due to the fact that the forms of *Poa imbecilla*, Forst., that occur in the more northerly parts of New Zealand are not typical of the prevalent state of the species. In the "Handbook of the Flora of New Zealand" (1867) both the above *Poas* are included, and the author concludes that both grow on the main islands, from which he had at first supposed *Poa breviglumis* to be absent. Though it is unlikely that he had good or abundant material to work on when the Handbook was in preparation, he recognised the close affinity of the two species, and even suggested that his *Poa breviglumis* might be a variety of *Poa imbecilla*, Forst. He further mentions that Banks and Solander referred the mainland forms of his *Poa breviglumis* to *Poa imbecilla*.

In his excellent "Manual of the New Zealand Flora," published in 1906, Mr. Cheeseman maintains the two species as distinct, but refers all the forms found on the main islands to *Poa imbecilla*, Forst. He mentions also that he had seen only a fragment of one of Hooker's specimens from Campbell Island, and some two or three others collected by Kirk and Chapman on the Auckland Islands. All these specimens I have, through Mr. Cheeseman's kindness, been able to examine.

The Philosophical Institute of Canterbury's expedition (November, 1907) for the exploration of the subantarctic islands of New Zealand secured no specimen of the grass, the visit being undertaken at too early a season.

In January of this year Mr. B. C. Aston, a most enthusiastic and capable collector, visited the subantarctic islands, and made a fine collection of all the grasses he met with, including a number of specimens of *Poa breviglumis*, from Enderby Island (in the Auckland Group) and from Campbell Island. These have been entrusted to me for examination, and the specimens appear to make the position of the plant quite clear. From a study of this material I conclude that *Poa breviglumis* is merely a form of *Poa imbecilla*, and that it is doubtful if it should be ranked as a distinct variety.

The descriptions in the "Flora Antarctica" and in Cheeseman's Manual lay emphasis on the prominent nervation of the flowering-glumes. I am unable to find in these glumes of *Poa breviglumis* anything to distinguish them in this or in other respects from those of *Poa imbecilla*. The fragment of one of Hooker's original specimens forwarded to Mr. Cheeseman from the Kew Herbarium agrees perfectly in the form of the flowering-glumes with those collected on the subantarctic islands by Kirk, Chapman, and Aston. In both the *Poas* under notice the nerves of the flowering-glumes are quite obscure, and it is only by transmitted light that they can be distinctly made out. The two lateral nerves are very close to the edge of the glume, and this added to their obscure appearance makes them difficult to observe readily by reflected light.

The nerves in the descriptions above referred to are said to be somewhat scaberulous; but in the large series of specimens I have examined it is very rare indeed for the nerves to be sensibly scaberulous, save on the keel.

A second differentiating character of some importance consists in the great inequality of the empty glumes in *Poa breviglumis*. My specimens of the entire series (including the two supposed species), both those from the main islands and those from the subantarctic islands, show considerable variation in the relative size of the empty glumes. In some of the Enderby Island specimens the lower empty glume is almost obsolete, while in quite a number of the Campbell Island ones it exactly matches the lower glume as it appears in the ordinary lowland forms of the series that are met with in the South Island. Moreover, the main-island forms not rarely show as marked a difference in the relative size of the empty glumes as obtains in specimens from the subantarctic islands.

A third differentiating character mentioned by Mr. Cheeseman is the "acute flowering-glumes" of *Poa breviglumis*. This character is, however, quite inconstant, and the variations it shows are matched by similar variations in the flowering-glumes of *Poa imbecilla*. In the original description of the species Hooker describes the flowering-glumes as "obtuse," and later, in the Handbook, he calls them "obtuse or acute." In the series of forms I have been able to study, these glumes are often acute or subacute; but obtuse flowering-glumes occur in the small specimens collected at some altitude on Campbell Island by Mr. Aston.

In specimens from the main islands and the subantarctic islands alike the panicle is subject to a great range of variation both in length and in form. In small forms only 3 in. or 4 in. high the panicle is short and compact, with shorter and broader spikelets that show smaller, blunter, and more coriaceous flowering-glumes. In other forms the grass is 9-15 in. high, with flaccid leaves and culms, and a panicle that is long, erect or nodding, lax, and ovate-oblong in outline. Others are intermediate in most of the above characters. The lower empty glume is especially variable in size, ranging from an almost obsolete condition to a narrow-ovate acute form, half as long as the upper empty glume, and occasionally even longer than this.

From what has been said it is evident that the differentiating characters of *Poa breviglumis* are quite inconstant, and that their variations correspond point by point with similar variations in *Poa imbecilla*. The gradations in the two plants are so complete and parallel that I cannot but conclude that the whole series forms a single species, well marked in general characters, but hardly capable of partition into stable varieties.

It is possible that the fragment of *Poa breviglumis* forwarded from Kew to Mr. Cheeseman does not really belong to that species, a doubt that the distinct absence of "prominent nerves" in the flowering-glumes compels one to entertain.

It is in the variety of *Poa imbecilla*, Forst., which I have described as "*Poa Matthewsii*" that the acute, prominently nerved, and scabrid flowering-glumes occur, but no specimen of this variety has so far been met with on the subantarctic islands. Whether *Poa Matthewsii* is to be regarded as a distinct species or not cannot be settled until more ample and better specimens are available. Probably some of the forms included in it may be more correctly placed under *Poa imbecilla*, Forst.; but the forms with the long, slender, strongly nerved spikelets stand on a different footing.

ART. XX. — *On the Naturalisation of* Calluna vulgaris, *Salisb., in the Taupo District.*

By D. PETRIE, M.A.

[*Read before the Auckland Institute, 22nd November, 1909.*]

DURING a short visit to the Taupo district early in February of this year I was told that the Scotch heather (*anglice*, ling) had become established near the Opepe Bush. I took occasion to visit the locality referred to, and found that this interesting introduction had secured a firm footing over an area of some two or three acres. The plants were in full flower, though most of them were still young, as the ground has repeatedly had fires run through it to clear off the manuka (*Leptospermum scoparium*, Forst.) that forms the natural plant covering of the district. The fires kill off all the older plants, but great numbers readily grow up from seed, and the species must be considered to have firmly established itself in this locality. How far it has spread by natural causes is at present uncertain, as I do not know how widely the seed was originally sown; but there is every prospect of its spreading readily, as the plant is well adapted to the habitat, and seedlings grow up in abundance. I was informed that the seed was sown by Major Roberts, till lately Stipendiary Magistrate at Tauranga, during the later part of the war with the Natives in Te Kooti's time. I have been unable to learn from this gentleman the time and circumstances of the sowing of the seed.

It is important that the introduction and establishment of such exotic plants as this should be noted, and its spread deserves to be watched. The land on which the heather grows is a flat dry terrace of pumiceous soil, such as one finds over most of the Taupo and Kaingaroa Plains. A very large area of similar country is available for it to invade. The spot where it is now established is about three-quarters of a mile from the small bush at which Mr. King has fixed his residence. To him I am chiefly indebted for such particulars about its introduction as I have been able to glean.

ART. XXI.—*Contributions to a Fuller Knowledge of the Flora of New Zealand: No. 3.*

By T. F. CHEESEMAN, F.L.S., F.Z.S., Curator of the Auckland Museum.

[*Read before the Auckland Institute, 22nd November, 1909.*]

As in the two previous instalments of notes bearing this title (see Trans. N.Z. Inst., vol. xxxix, p. 439; vol. xl, p. 271), I have to acknowledge my indebtedness to many friends and correspondents in various parts of the Dominion for much of the matter now placed on record. I particularly desire to mention my obligations to the late Mr. H. J. Matthews, whose position as head of the Forestry Department gave him many opportunities of obtaining information respecting the New Zealand flora, and who for years past has liberally supplied me with specimens, notes, and photographs. His decease will be greatly regretted by New Zealand botanists, by whom he was held in high esteem, not only for his many services to botanical science, but also for his amiable and genial disposition, the simplicity of his manners, and his truly lovable character.

I have also to express my thanks to the following gentlemen: to Mr. F. G. Gibbs, of Nelson, who has forwarded many interesting notes and specimens, mostly dealing with the botany of the north-western portion of the Nelson District; to Mr. B. C. Aston, of Wellington, for many specimens collected through almost the whole length of the Dominion; to Mr. R. H. Matthews, of Kaitaia; to Messrs. H. Carse, P, H. Allen, A. Allison, Rev. F. R. Spencer, F. N. R. Downard, J. H. Harvey, G. Williams, W. Townson, R. Mair, E. Linton, E. Clarke, C. Dawes, and others.

I. RANUNCULACEÆ.

Ranunculus Buchanani, Hook. f.

Abundant on the slopes of Mount Balloon, McKinnon's Pass, south-west Otago; altitude, 4,000 ft.; *H. J. Matthews! F. G. Gibbs!*

Ranunculus Matthewsii, Cheesem.

Southern slopes of Mount Balloon, a few hundred feet above the track over McKinnon's Pass; *H. J. Matthews!*

Ranunculus sericophyllus, Hook. f.

McKinnon's Pass, south-west Otago; 4,000 5,000 ft.; *H. J. Matthews! F. G. Gibbs!*

IV. VIOLACEÆ.

Hymenanthera novæ-zealandiæ, Hemsl.

Mr. W. B. Hemsley ("Kew Bulletin," 1908, p. 95) has pointed out that the New Zealand plant referred by Kirk and myself to the Norfolk Island *H. latifolia* is in reality distinct from that species. He states that the Norfolk Island plant has relatively more slender branches, thin entire leaves, smaller flowers, and the staminal appendages are only fringed at the tips instead of being minutely toothed all round the margin. Mr. Hemsley has also satisfied himself that Cunningham's *Scævola novæ-zealandiæ*, collected at Matauri Bay, opposite the Cavallos Islands, and which Hooker referred to his *H. crassifolia*, is really the same plant. That being so, Cunningham's specific name should be restored. Mr. Hemsley also suggests that the Chatham Islands' *H. chathamica* is not separated by characters of sufficient importance, and should be included in the circumscription of the species. As I have remarked in the Manual, it principally differs in the longer and narrower and much more sharply toothed leaves.

V. PITTOSPORACEÆ.

Pittosporum ellipticum, T. Kirk.

Mountain range south of Te Aroha; *F. N. R. Downard!* Differs from the typical form of the species in the narrower leaves and cream-coloured flowers, and may be deserving of varietal rank.

XI. TILIACEÆ.

Entelea arborescens, R. Br.

Plentiful on Fisherman's Island, a few miles from Motueka, Nelson; *F. G. Gibbs!*

XIV. RUTACEÆ.

Melicope ternata, Forst.

Bush at Wakapuaka, near Nelson; *F. G. Gibbs!*

XV. MELIACEÆ.

Dysoxylum spectabile, Hook. f.

Fairly plentiful on Pepin Island, a few miles north of Nelson; *F. G. Gibbs!*

XVII. STACKHOUSIACEÆ.

Stackhousia minima, Hook. f.

Spooner's Range, near Belgrove, Nelson; *F. G. Gibbs!*

XXIII. ROSACEÆ.

Geum uniflorum, Buch.

McKinnon's Pass, south-west Otago; *H. J. Matthews! F. G. Gibbs!* These are the first specimens I have seen from Otago. Mr. Petrie informs me that it has also been collected on the Takitimo Ranges, Southland.

Acæna glabra, Buch.

Black-birch Creek, Hooker Valley, Mount Cook District; *T. F. C.* McKinnon's Pass, south-west Otago; *F. G. Gibbs!*

XXIV. SAXIFRAGACEÆ.

Quintinia acutifolia, T. Kirk.

Mount Owen, Buller Valley; *F. G. Gibbs!*

XXVII. HALORAGACEÆ.

Dr. Schindler, in his recent monograph of the family ("Das Pflanzenreich," heft 23), makes a considerable number of changes in the nomenclature of the New Zealand species of *Haloragis*. As some of these appear to be of doubtful validity, I propose to make a few remarks upon them in this place.

Haloragis alata, Jacq.

Schindler adopts the specific name of *erecta*, which was published by Murray, under the genus *Cercodia*, in 1780, whereas Jacquin's name of *H. alata* did not appear until the following year. If the rules adopted by the Vienna Congress are to be accepted, the earliest specific name must be maintained, no matter in what genus it originated, however much we may regret the necessity of changing an old-established name like that of *H. alata*.

Haloragis cartilaginea, Cheesem.

In the Manual I reduced this to the position of a variety of *H. alata*, a view I am still inclined to hold. Dr. Schindler treats it as distinct.

Haloragis tetragyna, Labill.

Schindler considers that the Australian and New Zealand plants combined under this name by Hooker and Bentham are in reality distinct. Through the kindness of Dr. Maiden, who has forwarded me an excellent series of the Australian forms, I have been enabled to make a detailed comparison, and find that the New Zealand plant can usually be distinguished by its smaller average size, shorter and less pointed leaves, with fewer serratures, and larger and narrower fruit. As the name *tetragyna* must be retained for the Australian plant, to which it was first applied, Dr. Schindler proposes to adopt Buchanan's name of *H. aggregata* for our species. But this is inadmissible, for the following reasons: (1.) Because there is an earlier specific name of *incana*—*Cercodia incana*, A. Cunn., Prodr., n. 528 (1839); *Haloragis incana*, Walp., Rep. ii, 99 (1843)—which consequently takes precedence. (2.) Because *H. aggregata* is referable to *H. depressa*, and not to the series of forms included by Hooker under *H. tetragyna*. I possess one of Buchanan's type specimens, and there is another in Mr. Kirk's herbarium, both being clearly the same as *H. depressa*. Further, the plate of *H. aggregata* given by Buchanan (Trans. N.Z. Inst., iv, pl. 13) undoubtedly represents *H. depressa*, the fruit being shown to be tetragonous, with smooth interspaces between the ribs, exactly as in *H. depressa*. In *H. tetragyna* the interspaces are muricate or rugose. I hold, therefore, that the name to be used is *H. incana*, Walp.

In this place attention may be drawn to the remarkably distinct plant called by Hooker var. *diffusa*. This differs from the typical *H. incana* in the slender, much branched, procumbent or prostrate stems, and in the smaller, broader, and more obtuse leaves, with fewer serratures. These characters are constant throughout its entire range, which extends through almost the whole length of the Dominion, whereas typical *H. incana* has never been found to the south of Whangarei. I therefore think that it should receive the rank of a species, a view which has also been adopted by Dr. Cockayne in his report on the vegetation of Stewart Island (p. 57). Dr. Cockayne proposes the name of *H. diffusa*, but that is preoccupied by an Australian plant—*H. diffusa*, Diels in Engl. Bot. Jahr., xxxv (1904), 447. As the plant was excellently described and figured by Solander in his manuscript "Primitiæ Floræ Novæ Zealandiæ" under the name of *Cercodia procumbens*, I would suggest that it should bear the name of *Haloragis procumbens*.

Haloragis depressa, Walp.

Here, too, we are indebted to Dr. Schindler for pointing out that the Australian and New Zealand plants associated by Hooker and Bentham under the name of *H. depressa* must be separated. The New Zealand plant has rather large oblong-obovoid tetragonous fruit, with very large persistent styles, decurved between the calyx-lobes, whereas the Australian plant has small oblong barely tetragonous fruit, and the persistent styles are much smaller and erect. Schindler applies the name of *depressa* to the Australian species, using Kirk's name of *uniflora* for the New Zealand plant. Evidently he did not fully trace the history of the name *depressa*, or he must have noticed that it was first applied by Allan Cunningham to the New Zealand plant (*Goniocarpus depressus*, A. Cunn., Precur., n. 531). Consequently our plant must retain the name of *depressa*. Schindler divides the species into the two varieties, *genuina* (which is equivalent to *H. uniflora*, T. Kirk) and *bibracteolata*. But Cunningham's type certainly falls under the second variety, to which also Buchanan's *H. aggregata* must be referred. The two varieties will therefore be more correctly styled var. *a*, *aggregata*, and var. *b*, *uniflora*, the latter name being equivalent to Schindler's var. *genuina*. Kirk's name of *serpyllifolia* must be abandoned on account of the fact that the New Zealand plant differs from the Australian var. *serpyllifolia*.

Haloragis spicata, Petrie.

This is placed by Schindler as a variety of *H. depressa*. In the Manual I have hinted that this is its correct position.

The following arrangement is therefore the one which I now follow of the New Zealand species of *Haloragis* :—

1. *H. erecta*, Schindl. (*H. alata*, Jacq.).
2. *H. cartilaginea*, Cheesem. (*H. alata*, var. *cartilaginea*, Cheesem.).
3. *H. incana*, Walp. (*H. tetragyna*, Hook. f., non Labill, var. *a*; *H. aggregata*, Schindl., non Buch.).
4. *H. procumbens*, Cheesm. (*H. tetragyna*, var. *diffusa*, Hook. f.; *H. aggregata*, var. *diffusa*, Schindl.; *H. diffusa*, Cockayne, non Diels).
5. *H. depressa*, Walp. Var. *a*, *aggregata*, T. Kirk (*H. aggregata*, Buch., non Schindl.; *H. uniflora*, var. *bibracteolata*, Schindl.). Var. *b*, *uniflora*, Cheesm. (*H. uniflora*, T. Kirk; *H. uniflora*, var. *serpyllifolia*, T. Kirk, but not *H. depressa*, var. *serpyllifolia*, Benth.; *H. uniflora*, var. *genuina*, Schindl.). Var. *c*, *spicata*, Schindl. (*H. spicata*, Petrie).
6. *H. micrantha*, R. Br.

XXVIII. MYRTACEÆ.

Myrtus Ralphii, Hook. f.

Tauroa (Reef Point), near Ahipara, Mangonui County; *R. H. Matthews!* This is a marked extension of the range of this species, the northern limit of which had been believed to be at Whangarei.

XXIX. ONAGRACEÆ.

Epilobium pycnostachyum, Haussk.

Shingle-slopes on Ben Nevis, Nelson, and on Waingaro Peak, north-west Nelson; *F. G. Gibbs!* These are the most northern localities yet recorded.

XXXIII. Umbelliferæ.

Azorella.

Dr. Karl Domin, in a communication entitled "Ueber eine neue australantarktische Umbelliferen Gattung," published in Engler's "Botanische Jahrbucher" (vol. xl, p. 573), constitutes a separate genus of the whole of those species of *Azorella* included in Hooker's section *Schizeilema*, pointing out that the section is not only separated by a marked difference in habit, but by other characters of importance. There is much to be said in favour of Domin's views, which will probably receive the acceptance of New Zealand botanists. As characterized by him, the genus *Schizeilema* will include the whole of the species referred to *Azorella* in my "Manual of the New Zealand Flora," with the exception of *A. Selago*, which is a typical *Azorella*. It will also include two species from the extreme south of South America, and the Australian *Azorella Muelleri*, Benth. (*Schizeilema fragosum*, Domin). The following synopsis of the New Zealand species, abbreviated from Domin's memoir, will show his views regarding them.

Leaves 3–5-partite or -foliate.	
Leaflets distinctly petiolulate	1. *S. trifoliolatum.*
Divisions all sessile.	
Segments entire or nearly so	2. *S. nitens.*
Segments more or less cut, lobed or dentate.	
Fruit longer than its pedicel	3. *S. hydrocotyloides*
Fruit shorter than its pedicel.	
Involucral leaves obtuse.	
Stout; leaves coriaceous ..	4. *S. Roughii.*
Slender; leaves membranous ..	5. *S. pallidum.*
Involucral leaves acuminate ..	6. *S. Colensoi.*
Leaves undivided.	
Minute; leaves scarcely 2 mm. long	7. *S. exiguum.*
Large or small, but leaves always larger than above.	
Fruit longer than its pedicel	8. *S. reniforme.*
Fruit shorter than its pedicel	9. *S. Haastii.*
Smaller; leaves 5–10 mm.; fruit not much shorter than its pedicel	Ditto, subsp. *cyanopetalum.*
Larger; leaves 12–30 mm.; fruit 4 times shorter than its pedicel	Ditto, subsp. *Hookerianum.*

From the above it will be noticed that Domin adds an additional species (*S. Colensoi*) to those already known to inhabit the Dominion. It is based upon Hooker's *Azorella trifoliolata*, var. *b*, an obscure plant gathered by Colenso on crags at Titiokura, between Napier and Taupo, but which has not been observed since its first discovery more than sixty years ago. I have seen no specimens, and cannot express any opinion of my own as to the validity of the species; but as Dr. Domin has inspected the type in the Kew Herbarium, we may accept it on his authority. It should also be mentioned that Dr. Domin treats *S. Haastii* as a "collective species," dividing it into the two subspecies—*cyanopetalum*, which he distinguishes by its smaller size, leaf-blades 5–10 mm. diameter, fruit not much shorter than its pedicel, and blue petals; and *Hookerianum*, which is much larger, the lamina of the leaf being 12–30 mm. diameter, and the fruit often only a quarter the length of the pedicel. Now, there is no doubt that forms of *A. Haastii* can be found agreeing with these characters (except the blue petals, which I have never observed, and doubt the occurrence of in a fresh state), but whether these represent permanent varieties, separated by constant characters, appears to me to be highly doubtful.

Azorella nitens, Petrie.

Grassy places in the Cobb Valley, north-west Nelson; *F. G. Gibbs!* Not previously recorded to the north of the Clarence Valley.

Aciphylla Hectori, Buch.

McKinnon's Pass, near the base of Mount Balloon, forming hemispherical masses sometimes 2 ft. in diameter; *F. G. Gibbs!* I regret that Mr. Gibbs's specimens of this curious and little known species do not show either good flowers or fruit.

XXXIV. ARALIACEÆ.

Pseudopanax ferox, T. Kirk.

Tauroa (Reef Point), near Ahipara, Mangonui County; *R. H. Matthews!* A slight northward extension of the range of this fine plant, which, although it stretches throughout almost the whole length of the North and South Islands, is everywhere exceedingly local.

XXXV. CORNACEÆ.

Corokia Cotoneaster, Raoul.

Tasman Valley, Mount Cook district, ascending to 3,500 ft. altitude; *T. F. C.* Also in many other localities in the mountains of Nelson and Canterbury.

XXXVII. RUBIACEÆ.

Coprosma rugosa, Cheesem.

Arthur Valley and McKinnon's Pass, south-west Otago; *F. G. Gibbs!*

Nertera setulosa, Hook. f.

Vicinity of Marton; *W. Townson!*

XXXVIII. COMPOSITÆ.

Lagenophora pinnatifida, Hook. f.

Tauroa (Reef Point), near Ahipara, Mangonui County; *H. Carse!* This is an altogether unexpected extension of the range of this fine species, which had not been previously collected to the north of the Kaipara River. Mount Starveall, Nelson, plentiful; Flora Valley and Cobb Valley, north-west Nelson; *F. G. Gibbs!*

Celmisia Walkeri, T. Kirk.

Abundant on both sides of McKinnon's Pass; *H. J. Matthews!*

Celmisia rupestris, Cheesem.

Very plentiful on most of the high peaks flanking the Cobb Valley, north-west Nelson, especially on Waingaro Peak and the Diamond Lake Range; *F. G. Gibbs!*

Celmisia ramulosa, Hook. f.

McKinnon's Pass, south-west Otago; *H. J. Matthews! F. G. Gibbs!*

Celmisia lateralis, Buch.

Not uncommon on the mountains of north-west Nelson. Cobb Valley and adjacent mountains; Mount Cobb; Diamond Lake Range; mountains near the Heaphy River; *F. G. Gibbs!*

Celmisia Gibbsii, Cheesem.

Abundant on Waingaro Peak, north-west Nelson; *F. G. Gibbs!*

Celmisia petiolata, Hook. f.

Descends to sea-level in the sounds of the south-west coast of Otago; *H. J. Matthews.* The most abundant species in the Mount Cook district; *T. F. C.*

Celmisia Petriei, Cheesem.

Abundant on McKinnon's Pass and on the neighbouring mountains; *H. J. Matthews! F. G. Gibbs!*

Celmisia linearis, Armstr.

McKinnon's Pass; *H. J. Matthews!*

Celmisia Hectori, Hook. f.

An abundant plant on all the mountains in the Mount Cook district, forming extensive carpets in moist sheltered hollows; altitude, 4,500–6,000 ft.; *T. F. C.* McKinnon's Pass; *H. J. Matthews! F. G. Gibbs!*

Celmisia Macmahoni, T. Kirk.

On the precipitous face of Mount Rintoul, Nelson; *F. G. Gibbs!* The most western locality yet recorded.

Haastia Sinclairii, Hook. f.

Shingle-slopes on high peaks in the Mount Cook district; plentiful. Mount Ollivier, 5,500–6,000 ft.; *T. F. C.* Mount Kinsey, 5,000–7,000 ft.; *P. Graham.* Nun's Veil; *E. Linton!*

Raoulia glabra, Hook. f.

Mount Egmont; altitude, 4,500 ft.; *W. Townson!* The most northern locality yet recorded.

Raoulia subulata, Hook. f.

Mount Ollivier and other peaks in the Mount Cook district; altitude, 5,000–6,500 ft.; *T. F. C.!*

Raoulia Buchanani, T. Kirk.

McKinnon's Pass, south-west Otago; abundant; *H. J. Matthews! F. G. Gibbs!*

Helichrysum Leontopodium, Hook. f.

Grows most luxuriantly on Ben Nevis, eastern Nelson; *F. G. Gibbs!*

Senecio saxifragoides, Hook. f.

Kaikoura Peninsula, near the sea; *H. J. Matthews!*

Senecio Kirkii, Hook. f.

It is perhaps worth recording that this is an abundant plant on the lava-fields of the island of Rangitoto, often growing without protection among the bare basaltic rocks. It is usually an inhabitant of the forest, frequently growing as an epiphyte in the forks of the rata and other trees, associated with such plants as *Astelia, Freycinetia, Griselinia, Pittosporum cornifolium*, &c.

Senecio Monroi, Hook. f.

Limestone rocks by the Mason River, North Canterbury; *H. J. Matthews!*

Senecio revolutus, T. Kirk.

McKinnon's Pass, south-west Otago; *F. G. Gibbs!*

Senecio Adamsii, Cheesem.

Abundant on Waingaro Peak, north-west Nelson; *F. G. Gibbs!*

XLIII. EPACRIDACEÆ.

Leucopogon Richei, R. Br.

Near the North Cape; *E. Clarke!* A most interesting discovery, of which I have given full particulars in another part of this volume.

Archeria Traversii, Hook. f.

McKinnon's Pass, south-west Otago; *F. G. Gibbs!*

Dracophyllum Kirkii, Berggr.

Cobb Valley and adjacent mountains, north-west Nelson; *F. G. Gibbs!* The most northern locality yet recorded.

Dracophyllum uniflorum, Hook. f.

Mount Holdsworth, Tararua Range; altitude, 4,000–1,500 ft.; *W. Townson!*

XLIX. LOGANIACEÆ.

Geniostema ligustrifolium, A. Cunn.

Pepin Island, north of Nelson; *F. G. Gibbs.* This is the first record of the occurrence of this species in the Nelson Provincial District.

L. GENTIANACEÆ.

Gentiana Spenceri, T. Kirk.

McKinnon's Pass, south-west Otago; *F. G. Gibbs!*

LII. CONVOLVULACEÆ.

Ipomæa palmata, Forst.

Abundant on the cliffs at Whangamumu in 1853; *R. Mair.* Mr. Hansen has sent me fine flowering specimens from the Tiritiri Island locality mentioned in Trans. N.Z. Inst., xl, 280.

LIV. SCROPHULARIACEÆ.

Veronica elliptica, Forst.

Titahi Bay, near Cape Terawhiti; *B. C. Aston!* This is the first recorded locality from the North Island.

Veronica Cockayniana, Cheesem.

McKinnon's Pass, south-west Otago; *H. J. Matthews! F. G. Gibbs!*

Veronica salicornioides, Hook. f.

Abundant on the Cobb Valley, north-west Nelson, where it commonly attains a height of 6 ft.; *F. G. Gibbs! Captain Dorrien Smith!*

Veronica Petriei, T. Kirk.

Mountains above Lake Harris, Otago; *H. J. Matthews!*

Veronica Cheesemanii, Benth.

Occurs on all the higher mountains of eastern Nelson, as Mount Richmond, Mount Starveall, Ben Nevis, Gordon's Nob, &c.; *F. G. Gibbs!*

Ourisia prorepens, Petrie.

McKinnon's Pass, south-west Otago; *H. J. Matthews!*

LV. LENTIBULARIACEÆ.

Utricularia protrusa, Hook. f.

Waiharakeke Stream, near Morrinsville; *P. H. Allen!* Numerous specimens in full flower, being the first obtained in that condition since the original discovery of the species by Mr. Colenso in 1842.

LXIV. CHENOPODIACEÆ.

Rhagodia nutans, R. Br.

Abundant on Mackay's Bluff, near Nelson; *F. G. Gibbs!*

LXVI. PIPERACEÆ.

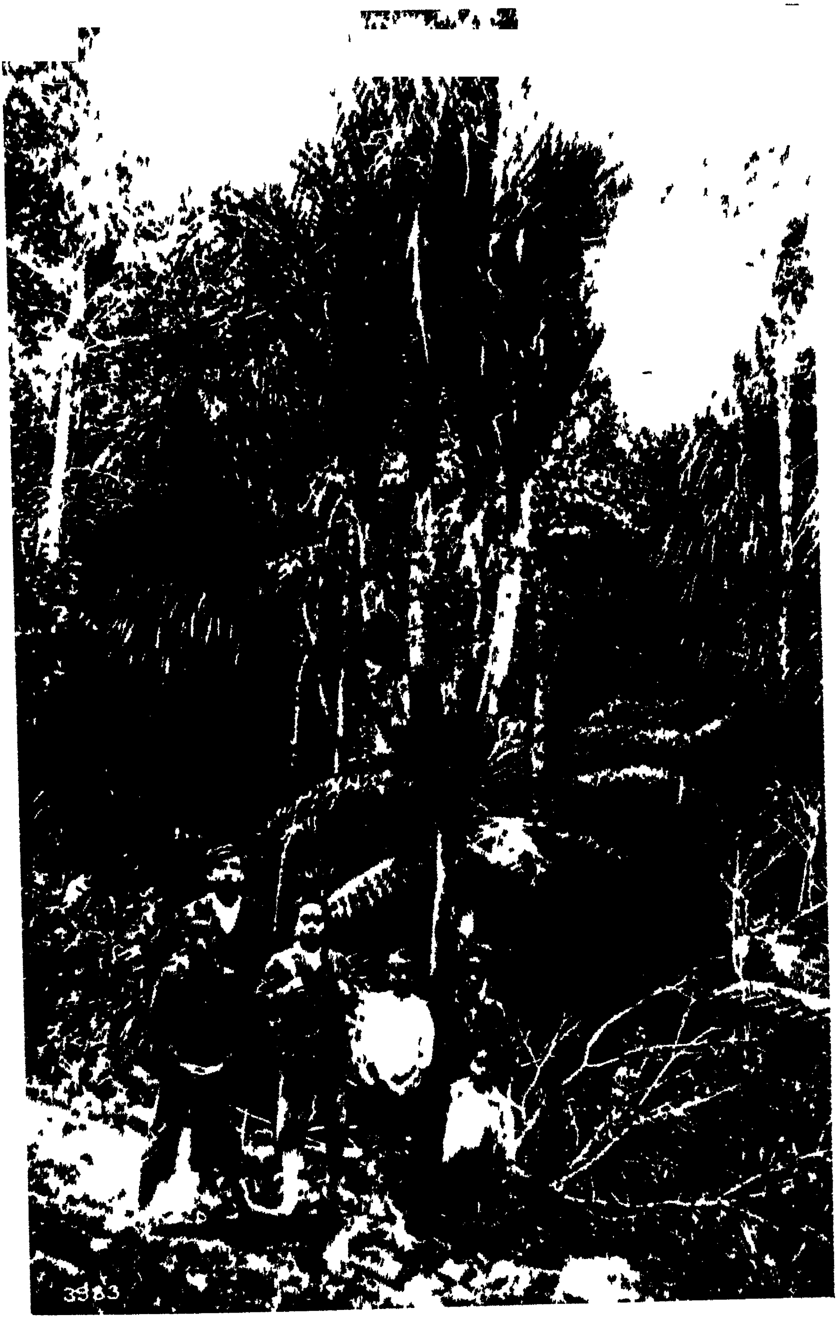
Peperomia reflexa, A. Dietr.

I am indebted to *Mr. Gerald T. Williams*, of Mokoiwi, near Tuparoa, East Cape district, for flowering specimens of this plant. He informs me that it is quite abundant in the valley of the Tuparoa River and its tributaries, extending to within four or five miles of the base of Mount Hikurangi. These valleys are warm and sheltered, and many coast plants like *Corynocarpus*, *Myoporum*, *Entelea*, &c., grow there with considerable luxuriance. *Peperomia reflexa* is found either on prostrate logs or on the trunks of living trees, sometimes as much as 30 ft. from the ground. According to Mr. Williams, it can often be seen clinging to the stems of *Metrosideros florida* and other woody climbers. There seems to be no reason why it should be confined to the East Cape district, but so far it has not been found in any other portion of the Dominion.

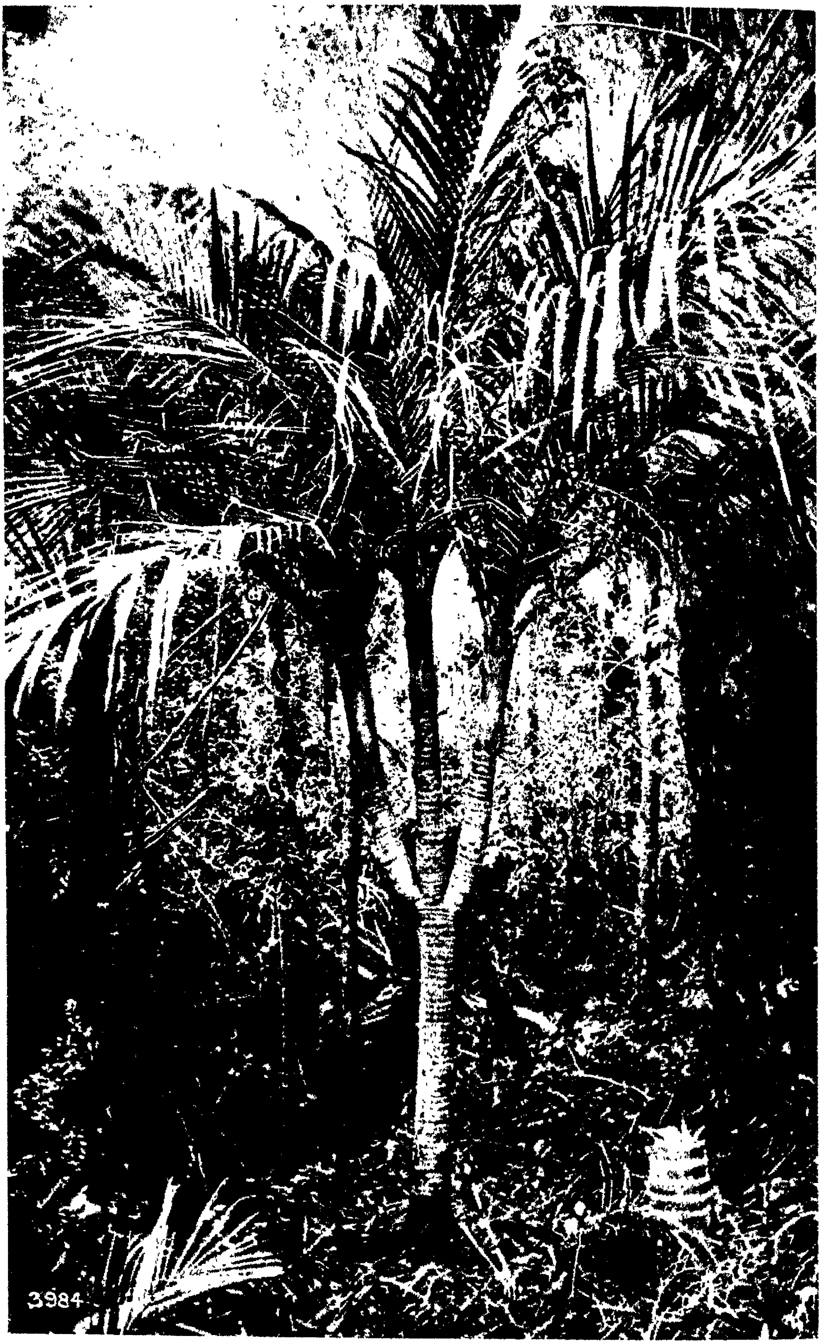
LXX. PROTEACEÆ.

Knightia excelsa, R. Br.

I am indebted to *Mr. A. Allison* for specimens of a curious sport, in which the leaves are dichotomously forked near the tips, somewhat after the manner of certain "crested" ferns. They were gathered at Orakeikorako by the Upper Waikato River.



BRANCHED NIKAU-PALM.—Cheeseman.



BRANCHED NIKAU-PALM.—Cheeseman.

LXXV. EUPHORBIACEÆ.

Poranthera microphylla, Brong.

Cobb Valley, north-west Nelson; *F. G. Gibbs!* These are the first specimens I have seen from this portion of the Nelson Provincial District.

LXXVI. URTICACEÆ.

Urtica ferox, Forst.

Summit of the ranges between the Thames Valley and Katikati, a few miles south of Te Aroha; *F. N. R. Downard!* The most northern locality yet recorded. Only a few specimens were seen.

LXXIX. ORCHIDACEÆ.

Pterostylis.

An interesting paper on the fertilisation of the Australian species of this genus, written by Mr. Oswald H. Sargent, is printed in the *Annals of Botany* for April, 1909.

Pterostylis foliata, Hook. f.

I am indebted to *Mr. Guthrie Smith* for fresh specimens of this species, collected at Tutira Lake, Hawke's Bay. They show that it varies greatly in size, the specimens ranging from 4 in. to 18 in. in height. The leaves are rather fleshy when fresh, and the reticulated veins are by no means obvious, except in dried specimens. A character that has not been previously mentioned is that the ovary and upper part of the peduncle are glandular-pubescent.

LXXXIV. PALMACEÆ.

Rhopalostylis sapida, Wendl. & Drude.

In the "Transactions of the New Zealand Institute" for 1906 (vol. xxxix, p. 447) I have briefly described and figured two curious branched specimens of the nikau-palm. Through the kindness of Mr. C. Dawes, of Kohukohu, Hokianga, I have received particulars of two more, photographs of which I reproduce herewith. One of the specimens has four branches springing almost from the same point; the other has three. Both trees are still growing in a patch of forest a few miles from Kohukohu. They are about 15 ft. in height, the diameter of the trunk not exceeding 9 in. (Plates XXVI and XXVII.)

XCI. CYPERACEÆ.

Schœnus Carsei, Cheesem.

Not uncommon in swamps by the Waitoa River, Thames Valley; *P. H. Allen!*

Carex and Uncinia.

A work of great importance to all followers of systematic botany has lately appeared in the shape of Kukenthal's "Monograph of the *Cyperaceæ-Caricoideæ,*" being heft 38 of Engler's "Pflanzenreich." The memoir forms a bulky volume of 824 pages, is profusely illustrated with drawings and analytical figures, and contains full descriptions of all the species accepted by the author. Dr. Kukenthal has long been known as a most capable and reliable botanist, and his acquaintance with the subject is unrivalled. Great expectations were therefore aroused as to the value and importance of his work, and it may at once be said that these have been fully realised. For the first time, botanists have been supplied with a systematic account of the *Caricoideæ* arranged with due regard to the affinities of the species, containing full and precise descriptions on modern lines, and with ample details of geographical distribution and other necessary factors. It appears to me that there are three reasons why New Zealand botanists are indebted to Dr. Kukenthal: First, for showing how far our species of *Caricoideæ* are allied to those found in other parts of the world, and what their relative positions are; second, in disposing of several dubious points of nomenclature that could only be authoritatively settled by reference to the botanical collections and libraries of the Northern Hemisphere; third, in giving the opinions of a botanist of wide training and experience, fully acquainted with the whole order, on the delimitation of the species. With respect to the first two of these, both of which are for the most part beyond the scope of inquiries that can be made in the Dominion, New Zealand botanists will gladly accept Dr. Kukenthal's conclusions. In regard to the third, which brings to the front the perennial difficulty of what constitutes a species—or, in other words, involves matters of opinion rather than matters of fact—the case is somewhat different; and I may be pardoned for presenting a few lines of explanation respecting some points on which I cannot quite agree with the learned author.

One of the chief merits of Kukenthal's memoir is that it is prepared on eminently safe and conservative lines. In this respect it is a pleasing contrast with some recent systematic work published in both Europe and America. But occasionally this conservatism appears to have been stretched too far. Taking the genus *Carex*, for instance, Kukenthal admits 669 species. But as far back as 1885 Bentham estimated the number of valid species at considerably over 500, and since then several hundreds have been described. Mr. C. B. Clarke has alone published over 150, and Dr. Kukenthal more than 80; while other authors are responsible for a considerable number. Several recent estimates have placed the number of valid species at from 800 to 1000. With regard to the New Zealand species, Dr. Kukenthal enumerates 43. This is 10 less than the number adopted in my "Manual of the New Zealand Flora." The difference has been caused by—(1) uniting *C. appressa*, *C. virgata*, and *C. secta* in one species under the name *C. appressa*; (2) by combining *C. Forsteri*, *C. Cockayniana*, and *C. semi-Forsteri* in the single species *C. Forsteri*; by merging *C. Buchanani* with *C. lucida*, *C. Solandri* with *C. dissita*, and *C. rubicunda* with *C. Petriei*; (1) by altogether omitting *C. Sinclairii*, *C. plesiostachys*, and *C. ventosa*. These are somewhat sweeping changes, involving a reduction of species that will hardly meet with the approval of New Zealand botanists as a whole. In the following notes I propose to discuss in some detail the chief alterations proposed. But before doing so I should like to say that no student of the New Zealand species of *Uncinia* and *Carex* can afford to be without a copy of Dr. Kukenthal's memoir. It is not only accurate and reliable, but contains much new matter, and many evidences of careful and painstaking research.

Uncinia Sinclairii, Boott.

Dr. Kukenthal considers this to be identical with the Fuegian *U. macrolepis*, Decne. et Hombr. in D'Urville Voy. au Pôle Sud, 3, t. *b*, f. A, and if so Decaisne's name will take precedence. I have not seen South American specimens, but Hombron's plate, quoted above, so closely resembles the New Zealand species as to leave little doubt of the accuracy of the identification. The late Mr. C. B. Clarke referred *U. macrolepis* to *U. Lechleriana*, but that is a species with much longer spikes.

Uncinia fusco-vaginata, Kukenth.

In the Manual I referred this to *U. purpurata* as var. *fusco-vaginata*, and I still think that it must be considered as a very near ally of that plant, although possibly entitled to specific rank.

Uncinia pedicellata, Kukenthal, n. sp.

This is based upon a plant collected by Dr. Cockayne on Ruapuke Island, in Foveaux Strait. I have seen no specimens, but according to Kukenthal's description it is closely allied to *U. australis*, differing mainly in the reddish foliage, narrower spikes, obtuse glumes, and obsoletely nerved utricles, which are conspicuously longer than the glumes. In *U. australis* the utricles seldom exceed the glumes, and are usually distinctly nerved. (Since writing the above, I find from Dr. Cockayne's memoir on the botany of Stewart Island that he regards it as common in lowland forests on that island.)

Uncinia australis, Pers.

Kukenthal adopts the name of *Uncinia uncinata* for this; the oldest specific name being *Carex uncinatus*, Linn. f., published in 1781. If priority of publication is alone to be considered, the change of name is unavoidable; but it may be pointed out that the new combination comes very near to being an infraction of article 55, section 2, of the Vienna rules of botanical nomenclature, under which it is provided that specific names shall be rejected when they merely repeat the generic name.

Uncinia riparia, R. Br.

The circumscription adopted by Kukenthal of this variable species agrees in the main with that given in the Manual, with the exception that he also includes Boott's *U. Hookeri*, from the Auckland and Campbell Islands, distinguishing it as var. *Hookeri*. When preparing the account of the genus given in the Manual I had no good material of *U. Hookeri*, and in default of such followed Hooker (Handb. N.Z. Fl. 310) in placing it under Raoul's *rupestris*. Since then I have received an excellent series of specimens collected by Mr. B. C. Aston, and can fully confirm Kukenthal's identification.

Uncinia nervosa, Boott.

Dr. Kukenthal considers that the New Zealand plant referred by me to this species is identical with Raoul's *U. rupestris*. I regret that I am unable to agree with this opinion, which is not shared by any other worker in the genus. I take it that *U. nervosa* naturally falls into the neighbourhood of *U. compacta*, whereas the true *rupestris* of Raoul, judging from his plate and description, is closely allied to *U. riparia*. This view was also held by Mr. C. B. Clarke, with whom I had some correspondence on the subject. In all probability Raoul's *rupestris* should be referred, as a variety, to *U. riparia*, and be placed in close association with var. *Hookeri*.

Carex teretiuscula, Good.

Kukenthal adopts the older name of *C. diandra*, Schrank, published in 1782, whereas *C. teretiuscula* did not appear until 1794.

Carex appressa, R. Br.

Kukenthal unites with this species both *C. virgata* and *C. secta.* There is much to be said in favour of this, for it cannot be denied that intermediate forms exist between the three plants, and also between *C. appressa* and the northern *C. paniculata.* In my revision of the New Zealand Carices, published in 1884, I therefore followed Baron Mueller and Mr. Bentham in placing all three under *C. paniculata.* But, as explained in the Manual, further consideration has led me to alter this opinion, and to keep the species separate. After all, the differences between the three plants are quite as well marked as those between several species of *Carex* admitted by most authors, and for the sake of consistency it appears best to uphold their distinctness.

Carex stellulata, Good.

In the Manual I followed Bentham and other well-known authors in adopting the name of *C. echinata,* Murr., for this species. But the late Mr. C. B. Clarke definitely proved that Murray's plant was identical with one of the forms of *C. muricata,* and Dr. Kukenthal has arrived at the same conclusion. Under these circumstances, botanists are pretty well agreed in taking up the next-oldest name of *C. stellulata,* Good.

Carex flava, Linn.

Kukenthal places the New Zealand form of this species under *C. Oederi,* Retz, as var. *cataractæ. C. Oederi* mainly differs from *C. flava* in the smaller size and shorter straight beak to the utricle. It is little more than a matter of taste as to whether the two species should be kept up or combined.

Carex Buchanani, Berggr.

Kukenthal reduces this to *C. lucida,* as var. *Buchanani,* a view with which I am unable to concur. *C. Buchanani* differs markedly in the much more strict and erect habit, in the semi-terete and much more coriaceous leaves, in the pale-coloured glumes, and in the plano-convex utricles, which are sharply serrate above, and have a much longer and more deeply bidentate beak. Not only is the aspect of the plant most distinct, so that it can be recognised at a glance, but its characters appear to me to be fairly constant. Dr. Kukenthal remarks that it is connected with *C. lucida* by numerous passage forms; but I have not myself met with specimens that could be so described. I feel sure that all New Zealand botanists familiar with the plant will repudiate any proposal to associate it with *C. lucida.*

Carex rubicunda, Petrie.

Kukenthal refers this to *C. Petriei,* as var. *rubicunda.* The late Mr. C. B. Clarke suggested that it should be placed with Berggren's *C. cirrhosa.* I have alluded to its affinity with *C. Petriei* in the Manual, and suspect that its reduction to that species will be maintained.

Carex Dallii, T. Kirk.

Probably a mere form of *C. Petriei,* Cheesem.

Carex plesiostachys, C. B. Clarke.

Not taken up by Kukenthal. I am now inclined to consider it a form of *C. comans,* Berggr.

Carex Solandri, Boott.

Reduced to *C. dissita* by Kukenthal as var. *Solandri.* No doubt there are transition states between the two plants—in the river valleys of north-west Nelson, for instance, where *C. Solandri* is particularly abundant, such may be commonly observed. But what I take to be the typical form is a much larger and more slender plant, with longer culms (sometimes over 5 ft. in length) that are often prostrate in fruit. The male spikelets (which are seldom more than one in *C. dissita*) are often as many as four or five; and the lower female spikelets are usually compound with long nodding peduncles. These characters recede so much from the ordinary state of *C. dissita* that I cannot refuse to regard the two plants as distinct.

Carex dissita, Sol., var. ochrosaocus, Cheesem.

Kukenthal unites this with the Norfolk Island *C. Neesiana*, placing it as var. *Neesiana* of *C. dissita.* A Norfolk Island specimen of *C. Neesiana* kindly forwarded to me many years ago by Baron Mueller does not seem to support this view; but the material is too scanty to form the basis of an opinion.

Carex ventosa, C. B. Clarke.

This is simply quoted by Kukenthal as a species unknown to him.

Carex Cockayniana, Kukenth.

Dr. Kukenthal now refers this to *C. Forsteri.* It is very much a matter of personal taste as to whether the two plants should be combined or kept apart. My own opinion is that the claims of *C. Cockayniana* to be regarded as distinct are quite as good as those of several species universally accepted.

Carex semi-Forsteri, C. B. Clarke.

This also is reduced to *C. Forsteri* by Kukenthal, but I feel sure that his material has been too scanty. As I have pointed out in the Manual, it has much of the habit of *C. Forsteri*, but the terminal spikelet is invariably largely female at the top, whereas it is wholly male in *C. Forsteri.* I reproduce herewith Mr. Clarke's original diagnosis, communicated to me in 1901.

"*C. semi-Forsteri*, n. sp.: Spicis 5–9, terminali pro magna parte fœminea, basi mascula, usque ad 4 6 cm. longis; glumis fœmineis (arista inclusa) cum utriculi subæquilongis; utriculis anguste ellipsoidei, trigonis, viridibus aut fusco-viridibus. 3½ 4 mm. longis, utrinque angustatis, glabris, 16-nervatis; rostro cum utriculi ½ ¾ parte fere aequilongo dentibus 2 linearibus patulis. New Zealand, Stephenson, n. 44, partim; Hooker, n. 4189; Colenso, n. 1622. Kermadec Islands. Shakespear, n. 1662."

XCII. GRAMINACEÆ.

Microlæna polynoda, Hook. f.

Tauroa (Reef Point), near Ahipara, Mangonui County; *R. H. Matthews!* Not previously recorded to the north of Whangarei Heads, where I collected it many years ago.

XCIII. FILICES.

Lomaria nigra, Col.

Maungataniwha Ranges, Mangonui County; *H. Carse.* Not previously recorded from the north of Whangarei.

Art. XXII.—*Notice of the Occurrence of* Leucopogon Richei, *R. Br., on the Mainland of New Zealand.*

By T. F. Cheeseman, F.L.S., Curator of the Auckland Museum.

[*Read before the Auckland Institute, 22nd November, 1909.*]

Leucopogon Richei was originally discovered by Lieutenant Riche, one of the officers of a French exploring expedition which, under the command of D'Entrecasteaux, visited Australia in the year 1792. It was first described by Labillardière in the well-known "Novæ Hollandiæ Plantarum Specimen" (vol. i, p. 44, t. 60). It was quickly found to have a wide distribution on the eastern and southern shores of Australia, stretching from the south of Queensland to Victoria, Tasmania, and South Australia, and from thence westward to King George's Sound and Swan River. So far as I am aware, it is strictly confined to littoral situations, never extending more than a few miles inland, and must be looked upon as one of the most characteristic of the coastal plants of Australia.

For its first discovery in the New Zealand area we are indebted to Mr. H. H. Travers, who gathered it on the Chatham Islands during his exploration of the group made towards the close of 1863. As is well known, the botanical collections made on this occasion were intrusted to the late Baron Mueller, and formed the foundation of his excellent little book entitled "The Vegetation of the Chatham Islands" (Melbourne, 1864). At page 45 Mueller records the occurrence of the species, stating that it was abundant on sandy ground near the sea on the main island, but was rare on the adjoining Pitt Island. Since then the plant has been collected or observed by all botanists visiting the group. I have specimens in my own herbarium gathered by Mr. Travers in his second expedition in 1871; by Captain G. Mair; by Mr. J. D. Enys, in 1887; by Miss Seddon, in 1895; and by Mr. F. A. D. Cox, at various times subsequent to 1896. Judging from Mr. Travers's statement in the "Transactions of the New Zealand Institute" (vol. i, p. 176), *Leucopogon Richei* is most abundant on the tracts of sandy soil which, as we know, are common on the Chatham Islands; but Dr. Cockayne, in his paper on "The Plant Covering of Chatham Island" (Trans. N.Z. Inst., xxxiv, 269), states that it occurs on limestone cliffs and on dry heathy ridges. In all probability it is well adapted for most dry and open situations in coastal districts, and consequently has a wide range of habitats.

Up to the present time, *Leucopogon Richei* has had the distinction of being the only Australian plant found in the Chatham Islands not also known as an inhabitant of the mainland of New Zealand. And it must be admitted that its occurrence on the Chathams, quite six hundred miles to the eastward of New Zealand, and its apparent absence in the latter country, situated between the Chathams and Australia, formed a somewhat puzzling problem in botanical geography. Personally, however, I have always considered it probable that it existed on some portion of our coast-line, and have made a practice of seeking for it on any botanical explorations of my own—always, however, without success. Consequently, I was very much interested and gratified to receive from Mr. Edward Clarke, of the Geological Survey, a few small specimens, in full flower, collected by him on the North Cape Peninsula. Mr. Clarke informs me that they were gathered close to Kerr Point, which is the north-western termination of the high table-like promontory which forms the North Cape proper. The plant appeared to be fairly plentiful, and was associated with the handsome *Veronica speciosa*, which grows in considerable quantities on the declivities leading from the top of the plateau to the edge of the cliffs. I may here remark that some years previously I passed over the actual locality where Mr. Clarke made his discovery, but without noticing the plant (see Trans. N.Z. Inst., xxix, 363). But in a flowerless state *Leucopogon Richei* might easily be taken for a stunted form of the much more common *L. fasciculatus*. Mr. Clarke's visit was fortunately made during the flowering season, when it would be impossible not to recognise the difference between the two species. *L. fasciculatus* has minute greenish-white flowers arranged in axillary or terminal *drooping* spikes. *L. Richei* has pure-white flowers, larger than those of *L. fasciculatus*, and these are arranged in short and dense many-flowered subterminal *erect* spikes. To say nothing of other important differences, this character of the inflorescence separates the two species at a glance.

The detection of *Leucopogon Richei* in the North Cape Peninsula recalls the discovery recently made by Mr. R. H. Matthews of the Chatham Island *Lepyrodia Traversii* in another part of the same district. For many years this plant was believed not to exist in New Zealand proper. It was, however, ultimately found in the middle Waikato by myself, and subsequently by Mr. R. H. Matthews in the peaty swamps between Lake Tongonge (near Kaitaia) and the sea. Other instances of Chatham Island plants found in isolated localities in the North Island are afforded by *Hymenanthera Traversii*, detected by Sir James Hector in the Inland Patea district; and *Pomaderris apetala*, which, as a native plant, is confined to two localities between Kawhia and Taranaki. The endemic *Corokia macrocarpa* and *Coprosma chathamica* are more nearly allied to northern species than to any other; and the occurrence in the Chatham Islands of *Rhopalostylis sapida* and *Cyathea Cunninghamii* are additional instances of northern affinity. In fact, the flora of the Chaham Islands has far more connections with that of the North Island than is commonly supposed, although its chief relationships are undoubtedly with the South Island. It is, however, somewhat remarkable that there is so little affinity with the flora of the islands to the south of New Zealand, especially when it is considered that Antipodes Island is almost as near to the Chathams as New Zealand. No doubt the difference in climate and geological structure has been a powerful factor, but it hardly seems sufficient to fully account for the facts of the case, which are not without their application to the previous history of the flora of both the Chathams and the Southern Islands.

I hope to recur to the subject at greater length in a further communication.

Art. XXIII.—*Some Recent Additions to the Flora of New Zealand.*

By T. F. Cheeseman, F.L.S., F.Z.S., Curator of the Auckland Museum.

[*Read before the Auckland Institute, 22nd November, 1909.*]

1. Olearia pachyphylla, Cheesem., n. sp.

O. furfuraceæ affinis sed foliis majoribus et multo coriaceis, capitulis longissimis, involucri bracteis multo numerosioribus.

Frutex 1·5–3 m. altus, rami robusti, angulati, sulcati. Folia 12·5 cm. longa, ovata vel ovato-oblonga, obtusa vel subacuta, valde coriacea, supra glaberrima, subtus densissime sed appresse sericeo-tomentosa; venis reticulatis. Capitula longissima, 1·5 cm.–1·8 cm. longa; involucri bracteæ numerosæ, 35–40, multiseriatæ, sericeo-tomentosæ, inferiores minutæ. Flores 7–10.

Hab.—North Island: Bay of Plenty, hills at Opape, on the road from Opotiki to Torere and Te Kaha; *Bishop Williams!* Flowers in March.

A much and closely branched shrub 4–8 ft. high; branches very stout, grooved and angled, the younger ones clothed with appressed brownish tomentum. Leaves alternate; blade 3–5 in. long by 2–2½ in. broad, ovate or oblong-ovate, obtuse or subacute, rounded and more or less unequal at the base, excessively thick and coriaceous, glabrous above, beneath clothed with densely appressed silvery or silvery-brown tomentum; margins entire but more or less undulate; veins finely reticulated beneath, less evident above; petiole stout, grooved, 1–1½ in. long. Corymbs much branched, 3–5 in. diameter; peduncles 4–6 in. long. Heads very numerous, ½–¾ in. long, narrow at the base but gradually widening upwards; scales of the involucre in very many series, densely imbricated, the lowest minute, the upper gradually larger, the whole more or less clothed with yellowish-brown woolly tomentum. Florets 7–10; ray-florets 3–5, disc-florets 4–6. Pappus hairs unequal in size, rigid, thickened and fimbriate at the tips. Achenes striate, silky-pubescent.

A very remarkable plant. In habit and foliage it much resembles *O. furfuracea*, and when out of flower might easily be taken for a robust large-leaved form of that species. But the flower-heads are altogether unlike those of *O. furfuracea*, or of any other species, being remarkable for their great length (quite ¾ in.) and the number of the involucral scales (35–45), which are imbricated in 6–8 series, thus giving the involucre an altogether different appearance from that of *O. furfuracea.* In that species the heads do not exceed ⅓ in., and the scales number 12–15.

For the discovery of the plant we are indebted to the Right Rev. W. L. Williams, late Bishop of Waiapu, who has done so much to elucidate the botany of the East Cape district, and who observed it at Opape several years ago. After several visits to the locality he succeeded in obtaining flowering specimens, from which the above description has been drawn up.

2. Raoulia Gibbsii, Cheesem., n. sp.

R. bryoidei proxima, sed differt ramis non densissime compactis, capitulis majoribus, floribus numerosioribus.

Planta formans cæspite 15–25 cm. diam. Rami numerosi, validi, laxe cæspitosi, suberecti vel decumbentes, dense imbricato-foliati, 4–10 cm.

longi, 5–10 mm. diam. Folia ut in *R. bryoidei*, sed multo majora, 5 mm. longa. Capitula terminales, sessilia, solitaria, 6–8 mm. diam.; involucri bracteæ 3-4-seriatæ, exteriores scariosæ, interiores apice albidæ. Flores numerosi, 12–20 feminei, 12–20 hermaphroditi. Achenia ut in *R. bryoidei*.

Hab.—South Island: Dun Mountain Range, Nelson, on Mount Starveall and Slaty Peak; altitudo, 4,000-5,000 ft.; *F. G. Gibbs!*

Forms small patches 6–9 in. diameter, much more laxly branched than is usual in the genus. Branches stout, erect or suberect, 2 5 in. long. with the leaves on ¼–⅓ in. diameter, not forming a hard compact mass as in *R. bryoides*. Leaves very closely imbricated, erecto-patent, ⅕–⅙ in. long, obovate-spathulate or rhomboid-spathulate, obtuse or subacute, upper half triangular, coriaceous, clothed on both surfaces with densely felted woolly hairs, which, as in *R. bryoides*, do not conceal the shape of the leaf; basal half membranous, upper surface glabrate or nearly so, lower surface slightly silky; margins furnished right to the base with long cottony hairs. Heads ⅜ in. diameter, solitary, terminal, sunk amongst the uppermost leaves; involucral bracts in 3-4 series, linear-oblong, scarious, acute, much smaller in proportion to the size of the head than in *R. bryoides*, and the inner ones with much less conspicuous white tips. Florets 20–40, the hermaphrodite about equal in number to the females. Achenes with long silky hairs and a conspicuous thickened areole. Pappus-hairs few, fragile, thickened at the tips.

Although this is technically closely allied to *R. bryoides*, in appearance it differs widely from that plant. *R. bryoides* forms hard and compact knobby masses in which the numerous branches are so closely packed that it is impossible to thrust the finger in between. *R. Gibbsii* is comparatively laxly branched, with longer, stouter, and more erect branches, and the leaves are much larger. The heads are also larger, with double the number of florets, and the scales of the involucre are proportionately smaller and less numerous.

Mr. Gibbs, who is the first to gather this interesting species, informs me that at a little distance it can be easily mistaken for a barren specimen of *Helichrysum grandiceps*.

3. **Myosotis (Exarrhena) Astoni**, Cheesem., n. sp.

Species *M. saxosæ* valde affinis a quo differt ramis et foliis multo longioribus, pilis laxioribus, floribus numerosis.

Perennis, undique pilis mollibus parce vestitus. Rami floriferi graciles, ascendentes vel basi decumbentes, 15–30 cm. alti. Folia radicalia numerosa, 5–10 cm. longa, supra et infra pilis brevibus parce obsita; folia caulina minora, sessilia. Racemi terminales, pedunculati, simplices vel furcati. Flores numerosi, breviter pedicellati. Corolla hypocrateriformis, 4–5 mm. diam.; tubus cylindraceus, fauce gibbis emarginatis instructa. Stamina 5, sub fauci affixa; filamentis elongatis.

Hab.—North Island: Mount Holdsworth, Tararua Range; altitude, 4,000–4,500 ft.; *W. Townson! B. C. Aston!*

Perennial, sparingly clothed with short soft hairs. Flowering-stems several from the root, slender, decumbent below, erect or ascending above, 6–12 in. long. Radical leaves few or many, 2–4 in. long; blade about half the length, ½–¾ in. broad, linear-obovate to oblong-obovate or oblong-spathulate, obtuse or subacute, thin and membranous, both surfaces sparsely clothed with soft white hairs; cauline much smaller, oblong or linear-oblong, sessile, or the lower alone shortly petiolate. Racemes pedunculate, simple or forked, many-flowered. Calyx hispid with soft white hairs; lobes erect, linear-oblong, subacute. Corolla funnel-shaped; tube equalling the calyx, throat with 5 scales; limb rather small. Stamens inserted just below the corolla-scales; filaments long, more than twice the length of the anthers, which reach more than half-way up the corolla-lobes. Nutlets ovoid, smooth and shining, dark brown.

I describe this species with considerable hesitation, on account of its evident close relationship to *M. saxosa*, a plant which has not been seen since its first discovery by Mr. Colenso, nearly sixty-five years ago. Judging from Hooker's description, however, it differs from that plant in the much larger size, more slender habit, fewer softer hairs, more numerous and larger flowers, and in the anthers not being exserted. I have much pleasure in dedicating it to Mr. Aston, who is doing so much towards increasing our knowledge of the botany of the Tararua Range.

Art. XXIV.—*The Absorption of Moisture from the Atmosphere by Wools.*

By A. M. Wright, F.C.S.

[*Read before the Philosophical Institute of Canterbury, 1st December, 1909.*]

Wool is very hygroscopic, and may contain from 8 up to 50 per cent. of moisture, according to the conditions of the atmosphere to which it is exposed. This is an important item in the sale of wool, and hence in Great Britain and on the Continent the percentage of moisture contained in wool to be sold must be officially determined in wool-conditioning laboratories.

The legal amount of moisture allowed in most European countries is 18·25 per cent.

The purposes of this investigation were—(1) To determine under what conditions wool absorbs moisture from the atmosphere; (2) to determine what constituents present in wool enable it to absorb such relatively large amounts of moisture.

The chemical composition of wool-fibre is nitrogenous, but we must distinguish between the true wool-fibre and the incrustating and mechanically adhering matters.

Pure wool-fibre consists for the most part of keratine, the characteristic constituent of horn, feathers, &c., and is not of constant chemical composition, but varying in different qualities and kinds of wool.

The incrustating and adhering matters consist of—(*a*) Wool-fat or yolk (soluble in hot alcohol); (*b*) other fatty matter (soluble in ether); (*c*) suint, which exudes from the body of the animal with the perspiration, and is sometimes known as "wool-perspiration" (soluble in water); (*d*) adhering impurities or dirt mechanically mixed with the above or entangled among the fibres (mechanically removed after extracting the fats).

The following are the analyses of the greasy and slipe wools of various kinds used in this investigation. The methods of analyses used are those described by the author,* with an additional method to determine the water-soluble suint. Suint was determined in the portion of the sample remaining after removal of the adhering sand and dirt. After drying and weighing, the sample was placed in a soxhlet extraction-thimble and repeatedly extracted with hot water; thereafter it was dried and weighed, the difference in weight from the previous weighing being suint, and the residue pure wool-fibre.

TABLE I.—GREASY WOOL.

—	Half-bred.	Three-quarter-bred.	Leicester.	Lincoln.
Moisture	16·90	19·20	17·79	17·18
Wool-fat	16·68	12·08	8·94	5·72
Other fatty matter ..	0·42	0·74	0·91	0·96
Water-soluble suint ..	10·30	12·72	7·81	2·26
Sand, dirt, lime, &c. ..	3·62	3·94	5·10	5·32
Pure wool-fibre ..	52·08	51·32	59·45	68·56
	100·00	100·00	100·00	100·00

TABLE II.—SLIPE WOOL.

—	Half-bred.	Three-quarter-bred.	Leicester.	Lincoln.
Moisture	12·78	12·82	13·37	12·67
Wool-fat	6·49	5·76	3·53	3·47
Other fatty matter ..	2·45	2·29	1·82	2·05
Water-soluble suint ..	2·01	1·60	1·20	1·04
Sand, dirt, lime, &c. ..	2·66	3·72	4·49	3·85
Pure wool-fibre ..	73·61	73·81	75·59	76·92
	100·00	100·00	100·00	100·00

It will be seen from the above analyses that the slipe wools contain a lower percentage of moisture than the greasy wools; the cause of this difference will be explained later. It is further seen that the amounts of wool-fat and suint are considerably less in the slipe wools; this is only to be expected, for in the washing of the skins these matters are removed.

The increase in fatty matters other than wool-fat is probably due to the fat and grease on the underside of the skin adhering to the wool in rubbing against the woolly side during the process of washing.

In determining the amount of moisture absorbed by greasy and slipe wools, the wools were dried absolutely, and, after weighing, were exposed to the atmosphere of the laboratory for from twenty-four hours to 408 hours, being weighed at regular intervals; at the same time determinations of the relative humidity and the amount of moisture in grains per cubic foot present in the atmosphere were made.

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* Jour. Soc. Chem. Ind., vol. xxvii, No. 3, 1909; Trans. N.Z. Inst, vol. xli, 1908.

The results obtained are presented in the following tables (the amounts of moisture absorbed by the wools are calculated to the moisture-free samples):—

TABLE III.—GREASY WOOL.

Time, in Hours.	Moisture absorbed, per Cent.	Relative Humidity.	Grains of Water per Cubic Foot.
24	24·38	80	3·6
32	29·27	85	5·2
48	27·77	85	4·4
72	26·82	72	3·8
144	28·66	82	3·9
168	26·62	76	3·8
192	27·36	85	3·8
216	25·79	70	2·7
240	24·85	65	4·3

TABLE IV.—SLIPE WOOL.

Time, in Hours.	Moisture absorbed, per Cent.	Relative Humidity.	Grains of Water per Cubic Foot
24	16·26	80	3·7
26	16·12	75	4·2
48	16·69	81	4·7
72	16·27	78	3·5
96	16·92	80	4·1
144	20·66	95	4·8
168	19·82	87	4·6
180	17·79	60	4·2
192	18·14	80	3·6
200	19·41	85	5·2
216	19·43	85	4·4
240	18·92	72	3·8
312	19·27	82	3·9
336	18·71	76	3·8
360	19·13	85	3·8
384	17·95	70	2·7
408	17·74	65	4·3

From the above results it is seen that the greasy wool absorbs from 24·38 to 29·27 per cent. moisture, whereas the slipe wool absorbs under the same conditions from 16·12 to 20·66 per cent. It is also seen that the amounts of moisture absorbed increase and decrease as the relative humidity rises and falls.

It is the relative humidity of the atmosphere rather than the absolute amount of moisture present which determines the amount of moisture which wool absorbs. From the above table it is seen that the amount of water per cubic foot of air bears but little direct relation to the moisture absorbed by the wool.

The amount of moisture absorbed by pure wool-fibre free from incrustations and adhering impurities was determined, and the results are shown as follows :—

TABLE V.—PURE WOOL-FIBRE.

Time, in Hours.	Moisture absorbed, per Cent.	Relative Humidity.	Grains of Water per Cubic Foot.
24	18·03	72	3·8
96	19·50	82	3·9
120	18·90	76	3·8
144	19·62	85	3·8
168	18·47	70	3·7
192	18·19	65	4·3

It is thus seen that pure wool-fibre, free from all other matters, absorbs from 18·03 to 19·62 per cent. of moisture from the atmosphere under varying degrees of humidity.

It is obvious from the above results that the pure wool-fibre cannot be the only matter in normal wool which causes the absorption of moisture, for in the greasy wool, containing from 50 to 60 per cent. of pure wool-fibre it is found that the absorption of moisture is from 24 to 29 per cent, whereas if the pure wool-fibre were the only factor we should expect to find a moisture-absorption of but from 9 to 12 per cent.; and in slipe wool, containing from 70 to 80 per cent. pure wool-fibre, we find a moisture absorption of from 16 to 20 per cent., whereas it should be only from 14 to 15 per cent. It is thus apparent that there are other factors which determine the amount of moisture absorbed.

It is probable that the relatively high amounts of moisture absorbed by pure wool-fibre is due to the very large surface-area presented to the atmosphere in proportion to the weight of the fibre.

A number of wool-fibres, each 3 in. long, were counted and weighed, and the following results calculated: 13,100 fibres of half-bred wool, each 3 in. long, weighs 1 gram; 12,500 fibres of three-quarter-bred, each 3 in. long, weighs 1 gram; 9,100 fibres of Leicester, each 3 in. long, weighs 1 gram; 7,800 fibres of Lincoln, each 3 in. long, weighs 1 gram.

If we take the average diameter of each of the above classes of wool as given in the following table, it will be found by calculation that the surface-area of 1 gram of wool is as follows :—

	Diameter.	Surface-area of 1 Gram.
Half-bred	0·0008 in.	98 sq. in.
Three-quarter-bred	0·0010 in.	118 sq. in.
Leicester	0·0016 in.	136 sq. in.
Lincoln	0·0018 in.	132 sq. in.

It will be seen that the large surface-area is an important factor in considering the relatively large amount of moisture absorbed by the fibre.

The wool-fat was examined, and it was found capable of absorbing up to 17·2 per cent. moisture when spread thinly on a watch-glass; but even with the inclusion of this factor it is not possible to account for more than 1 or 2 per cent. of the moisture absorbed by the normal wool-fibre.

The water-soluble suint, or wool-perspiration, was examined, with the result that it was found that very large amounts of moisture were absorbed by this constituent.

TABLE VI.—WATER-SOLUBLE SUINT.

Time, in Hours.	Moisture absorbed, per Cent.	Relative Humidity.	Grams of Water per Cubic Foot.
24	60·13	76	3·8
48	66·12	85	3·8
72	65·50	70	2·7
96	63·55	65	4·3
120	64·76	72	3·1
144	66·24	80	3·8

The results presented above show that here also the moisture absorbed varies with the relative humidity.

It is at once apparent that the suint, although present in amount of only 1 or 2 per cent. in some wools, and up to 12 per cent. in others, is responsible for a relatively large amount of moisture absorbed by the normal wool-fibres.

In slipe wools this material is largely washed out during the treatment of the skins, and its presence in greasy wools accounts for the increased power of moisture-absorption shown by these wools, and is an important factor in determining the amount of moisture that can be absorbed by the wool-fibre.

In determining the absorption of moisture by slipe wools it was found that the fatty matter other than wool-fat, which is present in slipe wool to a greater amount than in greasy wools, had the power of slightly retarding the absorption of moisture. This fatty matter, as has already been pointed out, is picked up by the wool from the greasy underside of skin during the washing process.

In the following experiments the natural wool-fat was first removed by extraction with hot alcohol, and the wool, after drying and weighing, was exposed to the atmosphere, and the amount of moisture absorbed determined; thereafter the other fatty matter was extracted with ether, and, after drying and weighing, was again exposed to the atmosphere under similar conditions of relative humidity, and the moisture absorbed noted.

In all cases the wool absorbed more moisture when the foreign fatty matter was removed than in its presence. The results obtained are shown in the following table:—

TABLE VII.

Foreign Fatty Matter.	Moisture absorbed in Presence of Fatty Matter, per Cent.	Moisture absorbed in Absence of Fatty Matter, per Cent.
2·06	10·70	11·07
2·16	9·38	9·92
2·60	9·22	9·98
2·88	9·98	10·18
3·28	9·95	11·13

It is probable that the fatty matter forms a film over the surface of the wool, and, being itself impervious to moisture, thus retards to a certain extent the moisture-absorption by the fibre and the other constituents of the wool.

Another point of considerable interest in connection with the foreign fatty matter present in slipe wool is that it is an oxidizable fat, and it is probably this fat which caused the rise in temperature in certain of the bales of wool experimented upon by the Wool Fires Commission,* Nos. 6 and 12.

In this connection it is of interest to refer to the reports by Mr. R. J. Friswell and Dr. J. S. Haldane† on these experiments.

Mr. Friswell states, "Another most interesting point is the fact that the oxidation of the grease by air and moisture (to which I attributed the fires on the s.s. "Gothic") is proved by these experiments. I have extracted the grease from Nos. 6 and 12, and have found it oxidized, and rubber- or varnish-like in character." Dr. J. S. Haldane states, "The results of the tests quoted in your letter are, I think, very instructive. They seem to me to point to this: that the rise in temperature of the bales was due to some substance (probably an oil) capable of combining with oxygen at a comparatively low temperature, and so producing heat; that the amount of this substance is very small, since the process practically comes to an end after about a fortnight, and that more or less of this substance was present in all the bales tested."

This fatty matter has been found in greater or smaller amounts in all slipe wools examined, but the amount present, while it is undoubtedly capable of producing heat by oxidation in the presence of air and moisture, is relatively so small that even should oxidation take place the heat generated cannot be very great. Where the amount of foreign fatty matter is high, of course a very serious danger does exist, as, for instance, in the case of a wool containing only from 6 to 10 per cent. moisture, but from 34 to 36 per cent. foreign fatty matter of an oxidizable nature.‡

SUMMARY.

The results of this investigation show that the amount of moisture which a wool can absorb from the atmosphere depends on several factors.

1. The relative humidity of the atmosphere determines the amount of moisture which a dry wool will absorb, more moisture being absorbed during a period of high relative humidity than when the humidity is low.

2. Pure wool-fibre, of which greasy wool contains from 50 to 70 per cent., and slipe wool about 75 per cent., can absorb from 18 to 20 per cent. of its weight of moisture from the atmosphere. This amount is not sufficient to account for all the moisture absorbed by the dry normal wool-fibre.

3. Natural wool-fat, present in greasy wool in amounts up to nearly 17 per cent., and in slipe wool to about 6½ per cent., is capable of absorbing about 17 per cent. of its weight of atmospheric moisture.

4. Suint, or wool-perspiration, can absorb from 60 to 67 per cent. of its weight of moisture when exposed to the atmosphere, this matter being very hygroscopic, and is present in greasy wools in amounts up to nearly 13 per cent., and in slipe wools to about 2 per cent.

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* Rept. Comm. on Fires on Wool-ships, Exhibit 40, p. lxxxvii.

† Supp. Rept. Comm. on Fires on Wool-ships, p. 6.

‡ Rept. Comm. on Fires on Wool-ships, p. lxxxv; Journ. Soc. Chem. Ind., vol. xxvii, No. 13.

5. Fatty matter other than natural wool-fat, present in slipe wools to an amount of from two to six times that found in greasy wools, and picked up by the wool from the greasy underside of the skins during the washing process, has a retarding effect on the amount of moisture absorbed.

By thoroughly washing wool, as in the case of slipe wools, not only are the incrustating and adhering matters washed out, and so a less weight of the product obtained, but a further deduction in weight has to be allowed for, because the wool is incapable of absorbing the same amount of moisture from the atmosphere which it could absorb in a greasy state, before the natural fat and suint were partially removed. The amount of moisture which slipe wool can absorb from the atmosphere does not reach the legal standard of 18·25 per cent. allowed.

For permission to publish these results the author desires to thank the Christchurch Meat Company (Limited), in whose chemical laboratory at Islington most of the work in connection with this investigation was carried out.

Art. XXV.—*The Formaldehyde Method for the Estimation of Nitrogen in Organic Substances.*

By A. M. Wright, F.C.S.

[Read before the Philosophical Institute of Canterbury, 1st December, 1909.]

The reaction between ammonia and formaldehyde, whereby hexamethylenetetramine is formed, has been used for some time as a means of estimating formaldehyde, but the reaction has only recently been utilised for the estimation of ammonia.

Bennett* has shown that the reaction can be made use of for the estimation of nitrogen in certain organic substances after digestion with sulphuric acid according to the well-known Kjeldahl method. He applied the method particularly to the determination of nitrogen in leather-factory control, and has shown that accurate results can be obtained for nitrogen in leather and tannery lime liquors.

The substance under examination is digested with sulphuric acid and sulphate of potash until the liquor is clear; the excess of acid is neutralised with sodium-hydrate solution, using phenolphthalein as the indicator; a neutral solution of formaldehyde is added, liberating the sulphuric acid present in combination with ammonia; hexamethylenetetramine is formed, which is neutral to phenolphthalein; the liberated acid is titrated with decinormal alkali-solution until the pink colour returns.

It is not so much claimed that this method effects a saving of time, but rather that no special apparatus is required for carrying out the determination, the whole operation being conducted in one flask.

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* Journ. Soc. Chem. Ind., vol. xxviii, 1909, pp. 291, 292.

The author has investigated this method as applied to the estimation of nitrogen in meat-products, organic nitrogen in fertilisers, and dried tankage and blood.

The following results were obtained, the amounts of nitrogen found by the formaldehyde method and the Kjeldahl method being shown :—

MEAT-EXTRACT.

	Nitrogen found (per Cent.).	
	Formaldehyde Method.	Kjeldahl Method.
Sample No. 1	8·44	8·42
,, 2	9·02	9·02
,, 3	8·76	8·76
,, 4	8·58	8·56

MIXED COMMERCIAL FERTILISERS.

Sample No. 1	4·23	4·23
,, 2	4·26	4·25
,, 3	2·74	2·74
,, 4	2·88	2·88
,, 5	3·96	3·98
,, 6	3·72	3·72
,, 7	4·25	4·27

DRIED TANKAGE.

Sample No. 1	7·26	7·25
,, 2	8·31	8·32
,, 3	6·72	6·72
,, 4	8·26	8·25
,, 5	7·33	7·33
,, 6	7·21	7·20
,, 7	8·08	8·08

DRIED BLOOD.

Sample No. 1	12·74	12·74
,, 2	13·22	13·20
,, 3	13·04	13·04
,, 4	14·26	14·26
,, 5	13·88	13·87
,, 6	14·52	14·52

For permission to publish these results the author desires to thank the Christchurch Meat Company (Limited), in whose laboratory at Islington most of the work in connection with this investigation was carried out.

ART. XXVI.—*Bionomic Observations on certain New Zealand* Diptera.

By DAVID MILLER.

[*Read before the Otago Institute, 8th June, 1909.*]

THIS paper is composed from the notes on the *Diptera* which I have collected in Otago during the last two seasons.* The species dealt with are to be found described in the "Synopsis of the *Diptera Brachycera* of New Zealand" (Trans. N.Z. Inst., vol. xxxiii), by the late Captain Hutton; those described elsewhere have the references attached. Only a few of the more common species are figured in colour in this paper, as diagrams and coloured plates of all the species will appear later in a series of papers which I hope to publish, dealing with both new species and those flies already described by Captain Hutton. Where it is deemed necessary, I insert a brief account of the general characters and habits of the families.

I am indebted to Professor Benham for his invaluable suggestions during the preparation of this paper.

To avoid repetition I shall here give a description of the general features of the localities mentioned:—

Ocean Beach forms the ocean side of the isthmus connecting Otago Peninsula with the mainland. This isthmus, which is about a mile in width, is formed, for the most part, of blown sand and alluvium, and is bounded on the opposite side to the beach by the mud-flats at the head of Otago Harbour. The sandhills of Ocean Beach are covered with lupin-bushes and marram-grass.

Tomahawk is separated from Ocean Beach by Lawyer's Head. Behind the sandhills of Tomahawk is a lagoon into which run the streams from the surrounding hills; the overflow finds a course over the sand to the sea. Lupin-bushes and marram-grass abound.

Purakanui is the district to the north of Otago Heads. The coast-line of this locality is formed of a series of precipitous headlands with intervening sandy beaches, behind each of which there generally exists a mud-flat or swamp fed by streams originating from the hills. Of these, *Murdering Beach* is a short strip of sand, surrounded by steep hills, and backed by a swamp in which rushes and other forms of vegetation grow. *Long Beach* is a stretch of sand of considerable length, and an extensive area of cultivated land (often under water) exists behind the sandhills. *Mapotaki Beach* faces the north (the last two face the north-east), and is somewhat similar in form to the preceding, differing in the fact that the sea gains an entrance to the mud-flat by a small stream which runs across the beach after draining the swamp. The surrounding hills of Purakanui are in places covered with what remains of the native vegetation.

Mount Cargill (2,232 ft.) is situated toward the north of Dunedin, and is still more or less covered by the native bush, which is either being felled or burned off.

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* Owing to the loss of a note-book, the remarks concerning several of the species mentioned below are somewhat meagre. However, since these observations went to press, additional facts have been collected for another paper, which I propose to publish as soon as possible.

The Nuggets is a rocky headland about sixty-five miles south-west of Dunedin. To the north of this headland are extensive stretches of sandy sea-beaches backed by dense native undergrowth ; in certain places swamps exist.

Barewood is situated inland, about twenty-five miles north-west of Dunedin, and about 820 ft. above sea-level. This locality is well named, the vegetation consisting of tussock, matagouri scrub, and a small plant with a yellow flower called the Maori onion (*Bulbinella Hookeri*). The Taieri River runs, in a deep gorge, through this locality.

Taieri Mouth is the name applied to the beach where the Taieri River meets the sea, about twenty-two miles south-west of Dunedin. This beach has much the same formation as that at the Nuggets.

Series ORTHORRHAPHA BRACHYCERA.

Fam. STRATIOMYIDÆ.

The members of this family inhabit flowers, and vary in size, some being small, while others are inclined to be large. Certain of the species are distinguished by the bright green of the abdomen.

Beris violacea.

This is a small species measuring about 4 mm. in length. I found a single specimen at the head of Mapotaki Bay in November (1907) ; this fly was resting on a bramble-bush growing near the mud-flat which is covered by the sea at high-tide.

Odontomyia chloris. (Plate XXVIII, fig. 1.)

Common during the season, but not to be observed in swarms. In January (1908) I captured two specimens on the sea-beach of Taieri Mouth, where, I think, they had been blown from the swamps behind the sandhills. The weather was very warm, sunny, and windy. At Roslyn, during February of the same year, I captured another specimen, which was at rest on a daisy exposed to the sun. Two more specimens were found in January (1909) on Murdering Beach, and under similar weather conditions to the preceding. Specimens of this species are common in gardens, and may be found in most situations.

Odontomyia collina.

About the same length as the preceding, but sometimes smaller, the sexes differing in size. One bright, warm, and windy day during December (1908) I captured a single specimen at Barewood, Central Otago.

Fam. ASILIDÆ (Robber-flies).

Robber-flies, the most predaceous form of *Diptera*, are, as a general rule, large insects which prey upon others. When a victim is captured, the asilid bores a hole in the thorax by means of the horny proboscis, and thus obtains the nutritive portions of the prey.

Saropogon fugiens. (Plate XXIX, fig. 4.)

During December (1907), at Taieri Mouth, this fly was exceedingly common. A number were captured among long grass near the bush. Vast numbers were found lying in a helpless condition at the margin of the sea, into which they had been blown by a strong offshore wind. I observed one specimen, which had been wet, struggle to a dry piece of sand (about a quarter of an inch in diameter), and, mounting this, stand up with its feet held closely together and stretch out its wings to dry in the wind. In this, I think, it would have been successful had it not happened that a wave coming up a little farther than usual enveloped the fly, and carried it back into the struggling mass of its fellows. As the tide went out there was left stretching along the beach a sinuous line composed of these flies and also representatives of other genera. Enormous numbers of *Diptera* are thus destroyed. When walking along Ocean Beach one day I was surprised to see a black continuous band stretching along the sand as far as the eye could reach; on examining it I found this dark line to be composed of myriads of small black flies belonging to the family *Mycetophilidæ*, which were evidently carried there by a strong breeze.

Saropogon hudsoni.

Found at Taieri Mouth in company with *S. fugiens.* I also captured a single specimen on Mount Cargill during February (1909); the weather was very hot and sunny, there being no wind.

Itamus varius. (Plate XXIX, fig. 6.)

Captured on the sea-beach at Taieri Mouth, January (1908). This fly was not then common: only a single representative was captured in this locality. It was more abundant at Barewood, Central Otago, where I captured several during December (1908). The specimens observed at Barewood would, when approached, either fly for a short distance and again alight or run into a tussock.

Fam. THEREVIDÆ.

The members of this family are not so active as those of the *Asilidæ*, but otherwise they agree in habits.

Anabarhynchus bilineatus.

Length, 16 mm. I captured a single specimen at Taieri Mouth, January (1908), and two on Murdering Beach during the same month of the following year. This species is not common; it is to be found on sandhills during warm weather.

Anabarhynchus micans.

Smaller than the preceding, being about 10 mm. in length. This species does not appear to be common, since only two specimens were found, on ivy, in the sun, at Roslyn, November (1907).

Fam. EMPIDIDÆ.

These flies are predaceous in their habits, and are seldom found in barren situations, on account of the presence in these localities of their more powerful allies, the *Asilidæ*.

Hilara fulvipes.

This is a small, abundant species, about 4 mm. in length, to be found in swarms hovering over bushes and flowers from November to February.

Fam. DOLICHOPODIDÆ.

The males of this family bear sexual ornamentations on the legs, head, the third joint of the antennæ, as well as on other parts. The species of this division are small.

Psilopus mobilus.

Very common in the bush at Taieri Mouth during January (1908). These flies were found, basking in the sun, on tree-trunks. I captured only two at Murdering Beach in January (1909), and these were resting on rushes which grew in a swamp behind the sandhills.

Series CYCLORRHAPHA ASCHIZA.

Fam. SYRPHIDÆ (Hover-flies).

The members of this family are both large and small, and are beautifully coloured with yellow and green. They are usually found hovering over flowers in the sun, and can be recognised by their mode of flight alone, which is described thus by Kirby: "They hover motionless in the air, and, if alarmed, dart off with a rapid motion that the eye cannot follow, and hover again as soon as they stay their course."* The larvæ are beneficial to gardeners, as they destroy large numbers of injurious insects.

Eristalis tenax (introduced).

Abundant everywhere from February to March; also found—but in decreasing numbers—in April and May. This species is found hovering about flowers in the sun. When it alights, the abdomen may often be seen moving up and down, and the wings are held in such a position as to expose the abdomen. I observed a specimen feeding on the pollen of a dandelion: the fly took hold of the stamen of a flower with its proboscis—which appears to be bifid at the distal extremity—and passed it once or twice up and down the stamen in order to rub off the pollen. After this operation had been indulged in two or three times, the fly held out its proboscis at full length, and moved the bifid portion as if it were in the act of tasting. Another specimen I observed to rest on the broken end of a holly-twig, by alighting so that the sharp edge of the broken twig came between the bases of the fore and middle legs; the fly steadied itself with the posterior tarsi pressed against the sides of the twig, while it cleaned its fore tarsi and proboscis; the middle legs meanwhile were outstretched. This specimen remained thus for about four minutes.

Helophilus trilineatus. (Plate XXIX, fig. 5.)

Not very common. I captured one specimen at Taieri Mouth in January (1908) as it alighted on a blade of grass in the sun. At Roslyn, during February of the same year, two were obtained resting on a marigold-flower exposed to the sun.

Helophilus antipodus.

Found at Roslyn, November (1908). I captured this species amongst some long grass in the sun, the day being very warm. A large number were observed hovering over a stream on Mount Cargill during February

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* I have lately observed a distinct difference between the flight of *S. novæ-zealandiæ* and that of *M fasciatum*: the movement of the former being jerky contrasted with the gliding motion of the latter.

(1909), and in the same month, as well as in March, several were captured on the hills of Purakanui. *H. antipodus* produces, during flight, a humming sound like that of a bee, but of a more acute tone.

Helophilus ineptus.

Common at Roslyn during February and March (1909). One very hot and sunny day in January I captured this fly on the banks of a small stream above Murdering Beach.

Helophilus chathamensis.

There is no record of this fly having been found before in New Zealand, since Captain Hutton's specimens were captured at the Chatham Islands. I found an individual on the sea-shore of Taieri Mouth, where it had been blown by a strong wind, in January (1908), and the following month I captured another hovering above a clump of marigold-flowers at Roslyn. On a small cliff at Tomahawk, during October (1908), a large number were taken while at rest on or hovering over some wild flowers attached to the rock; at the foot of this cliff a stream runs into the sea.

Helophilus latifrons.

Captured on a hillside near the bush at Taieri Mouth, December (1907). Two specimens were obtained at Roslyn during September (1908), and two more from Tomahawk in the following month.

Syrphus novæ-zealandiæ. (Plate XXIX, fig. 1.)

One of the most abundant of New Zealand Syrphids: it is to be found everywhere during the season, appearing about September and becoming less common in April; only a few are to be seen during May, and then only in sunny weather. This species varies greatly in colour. the yellow being in some a deep in others a very light shade. and may even be tinged with green. If a specimen be captured shortly after it has emerged from the pupa, the yellow spots are transparent, the black colour transmits the light, and thus the organs contained in the abdomen are rendered visible. I kept two specimens in confinement — a male and a female — for a few days. The male flew about more than the female, the latter feeding, most of the time, on the pollen of daisies which I had put in for food. These observations were made during May (1909), at which period the weather was becoming cold, so that the Syrphids were inert; but on the application of a little warmth they immediately showed signs of returning animation — the female returned to the flowers, while the male amused itself by endeavouring to find an exit. After a few minutes the female would stop feeding and stretch out the proboscis to its full length; this acticn having been accomplished once or twice, feeding was resumed; occasionally the fly would rub the proboscis with the fore tarsi. When this species alights, the wings are either held outstretched or folded over the abdomen, which is frequently kept in motion, as in *E. tenax.* On a drop of nitric acid being held about a quarter of an inch from the antennæ of a female, the fly immediately started back or dodged from side to side, endeavouring to avoid the acid; when held at the side of the thorax the acid did not appear to affect the specimen.

Syrphus ortas. (Plate XXIX, fig. 2.)

This species is rare. I have found only one specimen, which was resting on a dandelion exposed to the sun—Roslyn, September (1908).

Melanostoma fasciatum. (Plate XXIX, fig. 3.)

Common; usually to be observed from January to April. I found no specimens at Taieri Mouth at the beginning of 1907, but they were abundant at and round about Dunedin during January 1908. A large number were captured amongst long grass and upon rushes growing in swamp exposed to the sun.

Series CYCLORRHAPHA SCHIZOPHORA.

Division 1.—MUSCIDÆ CALYPTRATÆ.

Fam. ŒSTRIDÆ.

Gasterophilus hæmorrhoidalis (Bot-fly, introduced).

During February (1909) I observed a large swarm hovering about a young horse, attacking the animal at the knees and sides, and, as they flew about the place upon which they wished to alight, they would suddenly dart in and out, each time coming into contact with the horse's flesh.

Fam. TACHINIDÆ.

This is an extensive family, the members varying more or less in size; they abound in various situations, some in barren localities, others upon the inflorescences and leaves of plants; they are parasitic, at certain stages of development, upon the larvæ of other insects, thus being invaluable factors in the destruction of injurious species.

Macquartia subtilis.

Not common. This species was captured on a hillside near the bush at Taieri Mouth one very sunny day in December (1907).

Calcager turbidum.

A single specimen was captured amongst long grass in the evening, at Roslyn, February (1909), and another on the sandhills at Ocean Beach during May of the same year.

Hystricia lupina.

Very common on the tree-trunks of the bush at Taieri Mouth, December (1907), but I only found a single specimen on a flax-leaf at Tomahawk, October (1908).

Hystricia pachyprocta.

Captured in large numbers, together with the preceding, at Taieri Mouth, December (1907). I obtained another specimen at Mount Cargill, February (1909).

Occisor versutus.

Not common. I have only a single specimen, which was captured on Mount Cargill during February (1909).

Proscissio cana.

Not common. Specimens captured during December (1908) at Barewood, Central Otago.

Phorocera marginata.

Common. Captured on a red rata bush at Roslyn, September (1908), and on a laurel hedge during May (1909).

Phorocera tecta. (Hutton, Trans. N.Z. Inst., vol. xxxvi, p. 151.)

Common at Barewood, Central Otago, during December (1908).

Phania verecunda.

I have only obtained a single specimen of this species, which was captured by sweeping the net through long grass at Roslyn, February (1909).

Fam. SARCOPHAGIDÆ (Flesh-flies).

The members of this family are to be found upon decaying animal and vegetable matter.

Sarcophaga impatiens. (Plate XXVIII, fig. 2.)

This common fly is found in most situations. During December (1907), at Taieri Mouth, I captured a specimen near a swamp. About the middle of June (1908) I picked up another individual which was lying on the Tomahawk sea-beach, and several were obtained from the swamp behind Murdering Beach during January (1909), as well as from Long Beach during the two following months of the same year.

Fam. MUSCIDÆ (House-flies; Blow-flies).

Lucilia cæsar (Green Bottle-fly, introduced).

Abundant everywhere, living upon decaying animal matter.

Calliphora erythrocephala (introduced Blow-fly).

Abounds in all situations.

Calliphora quadrimaculata.

The common New Zealand blow-fly. Abundant throughout the season from about September onwards.

Calliphora hortona.

Common. During October (1908) I captured a large number on Ocean Beach. On stirring up the heaps of dried seaweed which lay about the sand above high-water mark I was surprised by the large numbers of this species which emerged, together with numerous semi-transparent flies. By examining the latter I found that they were specimens of *C. hortona* which had evidently just completed pupation. When first observed, the wings were crumpled or folded up longitudinally along the margin of the dorsal surface of the abdomen. At this stage the whole body was greyish in colour, and the abdomen, when held to the light, was seen to be semi-transparent. After about three hours the coloration of the mature fly began to develop: the abdomen became opaque and assumed the final blue tint, the thorax became gradually darker, the bristles took on their permanent colour, and the wings unfolded, the whole fly becoming transformed in colour. Before this transformation commenced, the ptilinum projected considerably, but was gradually withdrawn as the fly became mature. The wings of this species presented a peculiar appearance immediately after they had unfolded: two cross veins, connecting the first and second longitudinal veins, were absorbed as maturity approached. I have observed this structure in the wings of other genera.

Calliphora icela.

This species is common throughout the season.

Calliphora antennatis.

Evidently rare. I have captured three specimens in all—one at Ocean Beach, October (1908); a second on the beach at the Nuggets a few days later; and a third at Barewood, Central Otago, December (1908).

Calliphora læmica.

Found in most localities during the season; common.

Muscina stabulans.

Not uncommon. I captured a number at Roslyn during September (1908 and 1909); also in May and October (1908).

Fam. ANTHOMYIDÆ.

Trichophthicus maculipennis.

I captured a single specimen on a very warm day at Roslyn, February (1909).

Trichophthicus dolosus.

Three specimens were captured at Purakanui during January (1909), and two others at Dunedin in the following month.

Trichophthicus melas.

I captured one specimen during a very sunny day, at Roslyn, November (1908); two more were obtained from Mount Cargill, also during a sunny day in February (1909).

Trichophthicus limpidus.

Abundant. Found in a swamp at the Nuggets, October (1908), and captured in a swamp behind the sea-beach of Murdering Bay during January and February (1909).

Trichophthicus carbonarius.

Not very common. In October (1908) four specimens were obtained from a swamp at the Nuggets, and only one from among rushes, Purakanui, February (1909).

Trichophthicus ordinatus.

Two specimens were captured in a swamp at the Nuggets, October (1908).

Trichophthicus villosus. (Hutton, Trans. N.Z. Inst., vol. xxxiv, p. 171.)

Abundant. This fly is recorded from the Auckland Islands, but not from New Zealand, by Captain Hutton. Taken in large numbers from a swampy locality at Purakanui, January (1909).

Limnophora rapax. (Plate XXVIII, fig. 3.)

Common during December (1908) and January (1909) at Roslyn, and on the banks of a stream on Mount Cargill.

Homalomyia canicularis.

A common house-fly, which is introduced.

Homalomyia fraxinea.

Not common. Two specimens were captured on Mount Cargill, February (1909).

Cœnosia algivora.

This species was common on sandhills and patches of dried kelp during October (1908) at the Nuggets, and less common at Ocean Beach, March (1909).

Division II.—MUSCIDÆ ACALYPTRATÆ.

Fam. Phycodromidæ.

Cœlopa monstruosa.

Not common. Found on sea-beaches during the whole year, several being captured near the mud-flats at the head of Otago Harbour in the middle of winter (1909). If examined microscopically, the contents of the stomach are found to be composed of various portions of algæ, upon which the fly evidently feeds. This species is not very rapid in flight, and, since it only flies for a short distance near the ground, it can easily be run down; when on water it rests with the wings incumbent, and supports itself by placing the five tarsal joints along the surface. Being aquatic, this fly runs more rapidly on water than on land. If it happens to alight on its back, it wriggles about on the distal extremities of the long femora until it rights itself. The habits of this species are, generally speaking, sluggish.

Fam. Helomyzidæ.

Helomyza scutellata.

Common. Several specimens were captured on a window at the Nuggets during October (1908), and in the bush of the same locality; others were found in a swamp behind Murdering Beach, January (1909), and at Roslyn in February of the same year.

Fam. Sciomyzidæ.

Trigonometopus bipunctatus.

Common. Has been previously captured at the Chatham Islands, but not in New Zealand. Found in the same localities as *C. monstruosa*, and resembles that species in being aquatic as well as in its mode of flight. It burrows in the sand under the heaps of dried seaweed. This fly did not suffer from being placed in a jar of water which I kept agitated, and from which the specimen flew when the water was allowed to become smooth. I held another specimen under water for a short time (a minute and a quarter), but when released it rose to the surface, ran about for a few seconds, and flew away. This species is buoyed up by the numerous globules of air which adhere to the bristles and hairs.

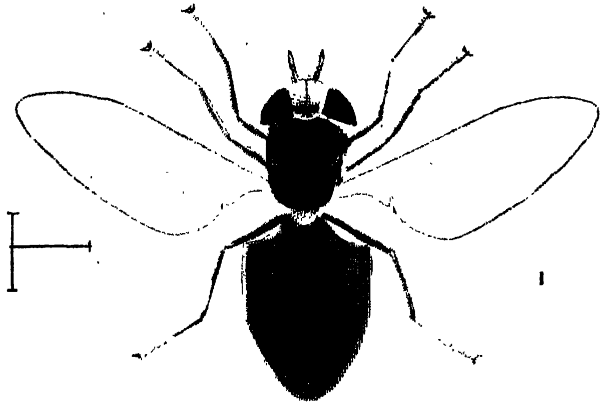
Fam. Sapromyzidæ.

Sapromyza dichromata.

Not uncommon.

Lauxania bilineata.

Abundant about Dunedin from November (1908) to February (1909). To be observed resting upon grass, lupin-bushes, and other forms of vegetation.



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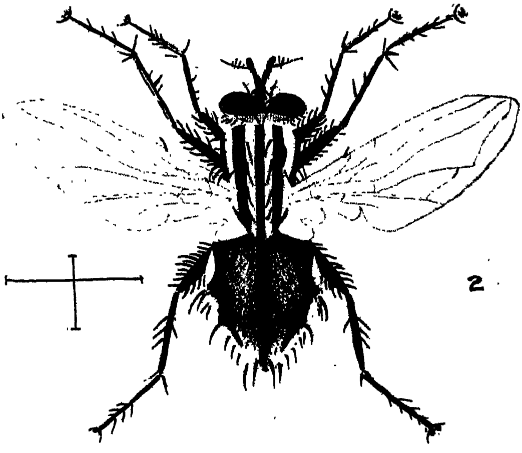

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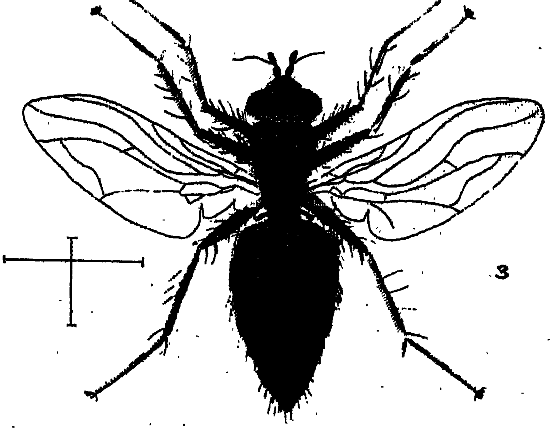

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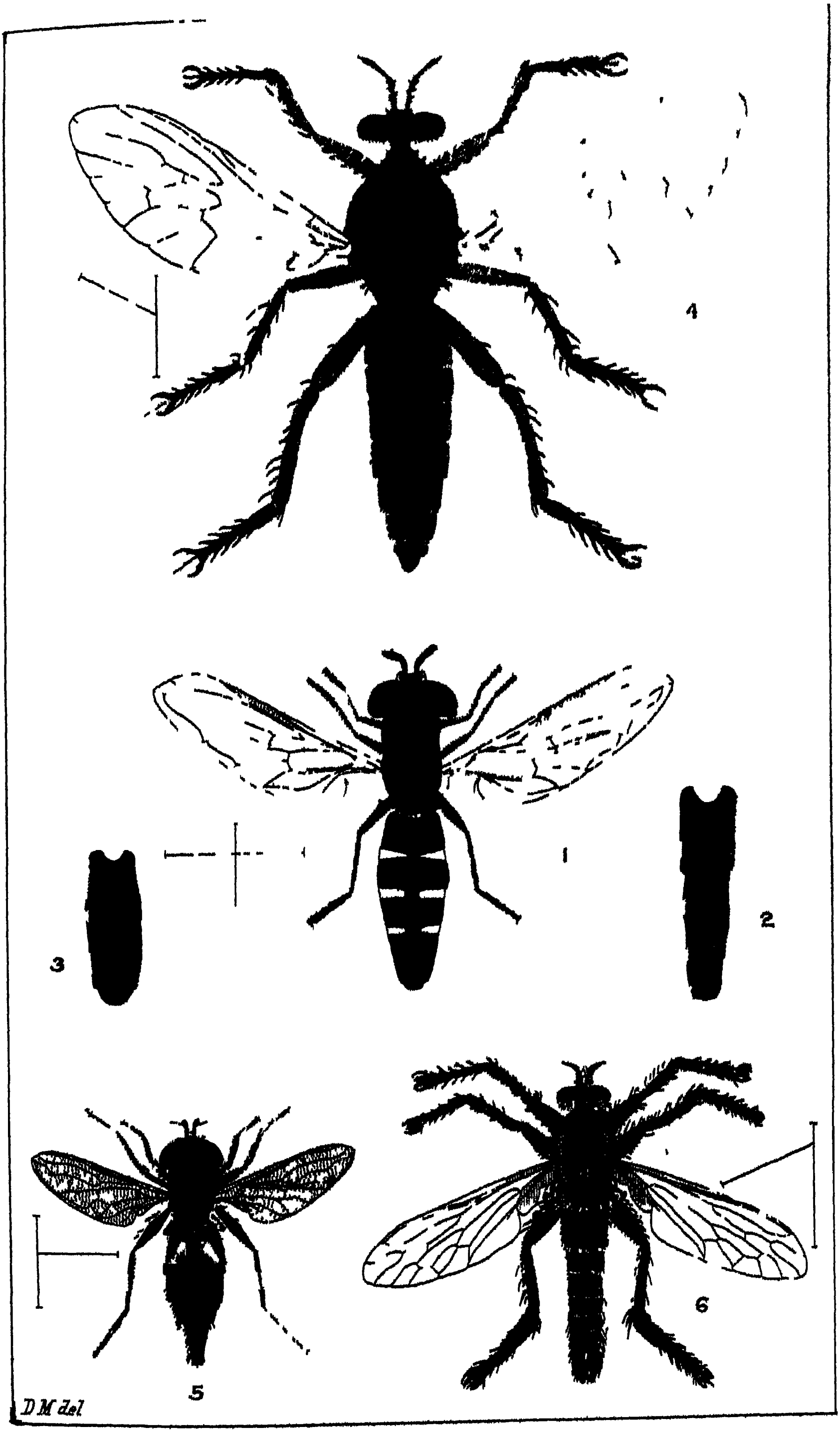
NEW ZEALAND DIPTERA.—Miller.



NEW ZEALAND DIPTERA.—Miller.

Fam. EPHYDRINIDÆ.

Ephydra aquaria.

An aquatic fly abounding on the surface of pools and on the damp banks of streams on the sea-shore. From my observations, they are to be found from January to May (1909). The larvæ live in saline pools on the sea-shore, and have been described by Dr. Benham in the Trans. N.Z. Inst., vol. xxxvii, p. 308.

Domina metallica.

A minute fly about 2 mm. in length. This species is not common, only two specimens having been obtained, during August and September (1908).

EXPLANATION OF PLATES XXVIII AND XXIX.

PLATE XXVIII.

Fig. 1. *Odontomyia chloris.*
Fig. 2. *Sarcophaga impatiens.*
Fig. 3. *Limnophora rapax*

PLATE XXIX.

Fig. 1. *Syrphus novæ-zealandiæ.*
Fig. 2. Abdomen of *Syrphus ortas.*
Fig. 3. Abdomen of *Melanostoma fasciatum.*
Fig. 4. *Saropogon fugiens.*
Fig. 5. *Helophilus trilineatus.*
Fig. 6. *Itamus varius.*

ART. XXVII.—*A New Species of* Empis.

By DAVID MILLER.

[Read before the Otago Institute, 12th October, 1909.]

THIS is the first of a series of papers dealing with new species of New Zealand *Diptera*, as they accumulate in my collection.

Fam. EMPIDIDÆ.

Genus EMPIS, Linæus.

Hutton, Trans. N.Z. Inst., vol. xxxiii, p. 30.

Empis otakouensis,* sp. nov.

Male and female. Head spherical (fig. 2), borne by a short neck; eyes bare, dichoptic; ocelli present; occiput with short bristles, elongated at the ocelli to form two pairs of vertical and a single pair of post-vertical bristles, directed forward; fronto-orbital bristles short, extending to the base of the antennæ; frons, vertex, and occiput dark brown, covered with silvery-grey tomentum; first and second joints (*e*, *f*) of antennæ bristly, not elongate, same colour as the frons, third joint (*c*) not bristly, elongated, darker than the preceding, bearing a shorter terminal style (*d*); face covered with silvery tomentum, oral margin surrounded by long silvery hairs which extend posteriorly toward the occiput; proboscis (*a*) rigid, tapering to a point which is bifid, directed downwards, about one and three-quarters the length of the head, dark brown, shiny; palpi (*b*) about as long as the proboscis, club-shaped, silvery grey, bearing long silvery hairs.

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* The name "*otakouensis*" is derived from that of a Maori village known as Otakou, situated a short distance from Taiaroa Head, and not far from the locality where this species was found.

Thorax: pleuræ brown, covered with silvery tomentum; metapleuræ with a tuft of hair, dorsum brown, with two darker longitudinal stripes; bristles short anteriorly, but longer posteriorly; a medium-sized bristle on each of the alar frena near the wing-bases; humeri silvery, as also are the hairs and the margin of the dorsum; scutellum silvery grey, with several medium-sized marginal bristles; halteres light brown. Wings tinged with grey, veins brown and faintly margined with brown, main vein grey toward the base, a brown elongate spot at the junction of the first longitudinal with the costa (fig. 1), fork of third longitudinal vein curved forward before meeting the costa; auxiliary vein evanescent at the tip so as not to meet the costa. Legs covered with weak bristles and silvery hairs, the posterior pair being the longest; coxæ same colour as the pleuræ, not elongate; femora, tibiæ, and tarsi very dark, almost black in certain lights, covered with grey tomentum and with silvery reflections, the posterior metatarsi (*a*, fig. 4) and distal extremity of the femora (*b*) swollen; pulvilli and ungues distinct.

Abdomen linear, grey, margins of segments with silvery hairs, longer in the male, a system of black spots on each segment, a row existing along the anterior margin together with two median pairs, one on each side toward the margin (fig. 6). Genitalia of male (fig. 3) much swollen, recurved dorsally, covered with long hairs, bearing two sets of shiny reddish-brown claws (*b*); abdomen of female tapering to a dark point bearing a clump of short bristles directed forward (fig. 5).

Length of ♂ and ♀, 8 mm.; of wing, 7½ mm.

Hab.—Common during the summer on the sandhills of the sea-beach, having been captured on Murdering Beach during January, and also on Ocean Beach in the following month (1909).

EXPLANATION OF PLATE XXX.

Fig. 1. Plan of venation of the wing (magnified).

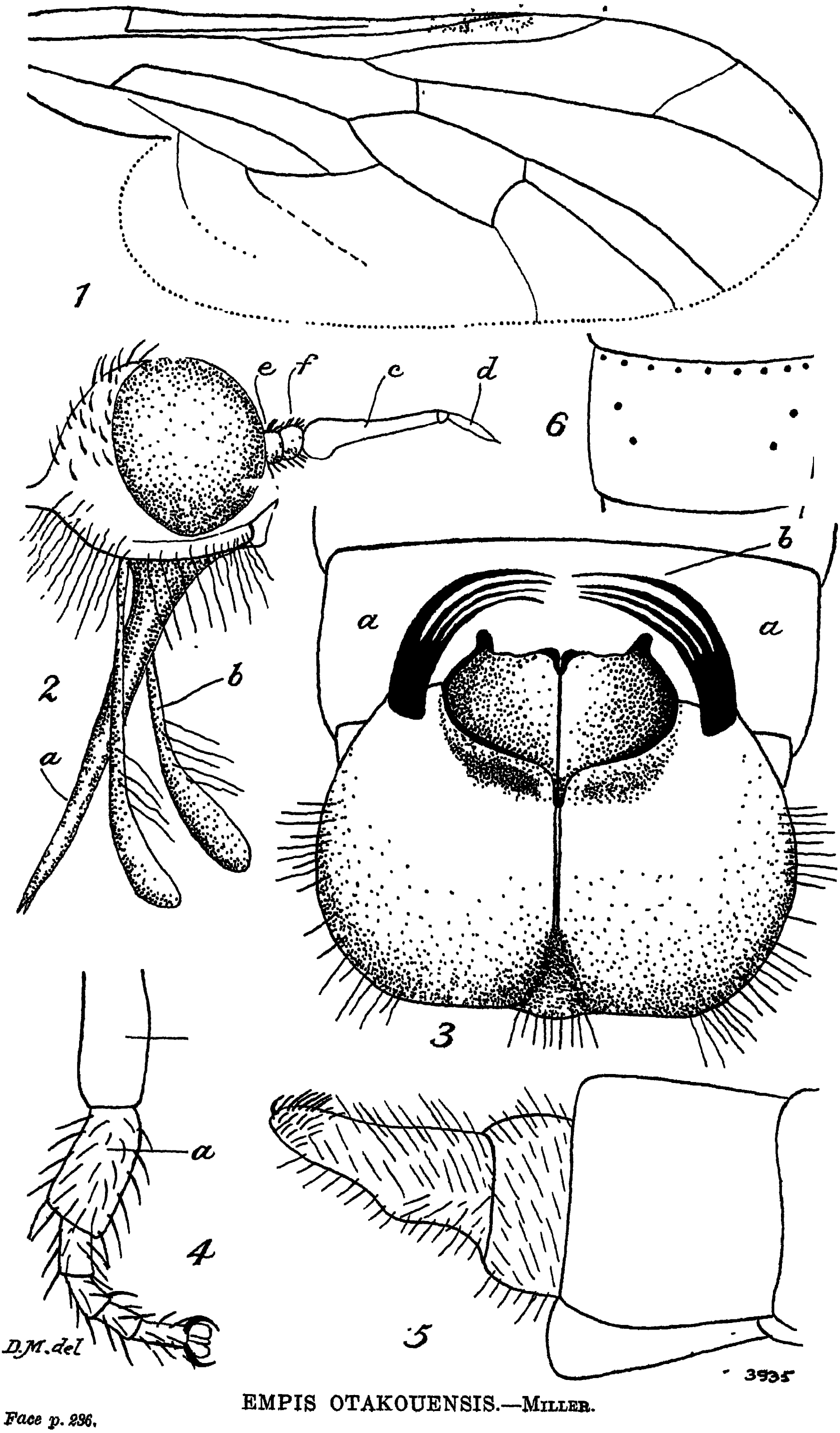
Fig. 2. Side view of head: *a*, proboscis; *b*, palpi; *e*, *f*, 1st, 2nd antennal joints; *c*, 3rd joint; *d*, terminal stylo (magnified).

Fig. 3. Dorsal view of male genitalia, showing the claws (*b*) and abdominal segments (*a*) (magnified).

Fig. 4. Posterior leg of male, showing portion of femora (*b*) and swollen metatarsus (*a*) (magnified).

Fig. 5. Side view of the posterior abdominal segments of a female (magnified).

Fig. 6. Dorsal view of 6th abdominal segment, showing the arrangement of the spots (magnified).



EMPIS OTAKOUENSIS.—Miller.

ART. XXVIII.—*On the Influence of Ripples on the Gas Content of the Artesian Waters of Christchurch.*

By C. COLERIDGE FARR, D.Sc., and D. C. H. FLORANCE, M.A., M.Sc.

[*Read before the Philosophical Institute of Canterbury, 6th October*, 1909.]

THIS paper may be regarded as a continuation of a paper read before the Institute on the 13th July. The work was undertaken to ascertain the gas content of some of the artesians about Christchurch, and how quickly the content was altered to the normally saturated condition by rippling over obstacles. The wells examined were the Museum well and the well at the fish-hatcheries. At the Museum a series of four boxes was placed so that the water ran from one to the other in open channels. The distances were: From box 1 (into which the water ran direct from the well) to box 2, 3 ft.; box 2 to box 3, 6 ft.; and box 3 to box 4, 5 ft. The gas contents of these were all examined several times, with the following results:—

	Determination. C.c. per Litre at N.P.T. 1.	 2.	 3.
Box No. 1,—			
Nitrogen, argon, &c. ..	18·45	18·65	18·45
Oxygen	3·90	4·60	4·40
Carbon-dioxide	1·00	1·40	1·10
Box No. 2,—			
Nitrogen, argon, &c. ..	18·16	16·84	18·30
Oxygen	5·00	5·80	5·00
Carbon-dioxide	1·20	1·80	1·20
Box No. 3,—			
Nitrogen, argon, &c. ..	17·36	18·26	..
Oxygen	4·94	5·06	..
Carbon-dioxide	1·30	0·06	..
Box No. 4,—			
Nitrogen, argon, &c. ..	17·20	17·82	..
Oxygen	5·20	5·28	..
Carbon-dioxide	1·30	0·76	..

Temperature of well, 12·8 C.

The means of these are,—

Box No. 1,—		Box No. 3,—	
Nitrogen, argon, &c. ..	18·52	Nitrogen, argon, &c. ..	17·81
Oxygen	4·30	Oxygen	5·00
Carbon-dioxide ..	1·19	Carbon-dioxide ..	0·95
Box No. 2,—		Box No. 4,—	
Nitrogen, argon, &c. ..	17·76	Nitrogen, argon, &c. ..	17·51
Oxygen	5·27	Oxygen	5·24
Carbon-dioxide ..	1·40	Carbon-dioxide ..	1·03

Throughout this work the CO_2 includes also any that might be given off by bicarbonates in solution on heating.

Tests were made for SH_2 and SO_2, which showed that there was no appreciable quantity of either present.

Gas Content of Water at Fish-hatchery.—The water in the Acclimatisation Society's hatchery boxes was also examined, the top box of the series being previously examined for radio-activity, and also the bottom being tested.

	Determination. C.c. per Litre at N.P.T. 1.	2.	3.
Top box,—			
Nitrogen, argon, &c. ..	16·00	16·85	17·60
Oxygen	5·80	5·22	5·00
Carbon-dioxide	2·18	1·61	1·60
Bottom box,—			
Nitrogen, argon, &c. ..	16·70	15·30	15·95
Oxygen	6·10	5·30	5·65
Carbon-dioxide	1·16	2·30	2·18

Temperature of well, 12·7 C.

The means of these are,—

Top box,—		Bottom box,—	
Nitrogen, argon, &c. ..	16·82	Nitrogen, argon, &c. ..	15·98
Oxygen	5·34	Oxygen	5·68
Carbon-dioxide ..	1·80	Carbon-dioxide ..	1·88

As a check, the water of the Avon was examined, and the gas content found as follows:—

	C.c. per Litre at N.P.T.
Nitrogen, argon, &c.	15·36
Oxygen	7·74
Carbon-dioxide	1·30

Temperature, 11·4 C.

which are just about ordinary saturation values at the temperature.

From the above it appears that the gas content of these wells varies within small limits, as we are of opinion that the different values obtained in the several determinations of the same water are real, and are not to be ascribed to errors. It also appears from the mean values that the effect of rippling is to diminish the nitrogen content and to increase the amount of oxygen; and, whilst the top box of the series at the hatchery contains an excess of nitrogen over river values of 1·4 c.c. per litre, and of oxygen a deficit of 2·4 c.c. per litre, at the bottom box these are altered to nitrogen in excess 0·62, and oxygen in defect 1·06.

As the cause of this part of these experiments was the peculiar mortality to be found amongst trout confined close to a well, the facts regarding this mortality may be briefly restated.

Of trout confined near the Museum well, a very large proportion die within a few days. Of those not dying, few escape what is known as "pop-eye," a disease which manifests itself by a protrusion of the eyeball. This disease has been ascribed by Marsh and Goreham to an excess of gas, chiefly nitrogen, in the water.

Of eggs hatched in the boxes we have examined at the hatchery a considerable proportion die, and the mortality in the egg-state diminishes rapidly over the series of boxes, of which the first and fifth have been examined for gas content. The figures relating to these were given previously.

Blue Swelling. — This disease attacks the young trout in the yolk-sac stage, and, like the three previously mentioned, its effects seem to fall off rapidly as the young fry are removed farther from the well-pipe. The yolk-sac develops a bluish portion, and an examination of this shows it to be filled with a fluid, and not with a gas.

With regard to the mortality amongst the ova, and the blue swelling, some experiments, which were in progress at the time the previous paper was read, have, with the aid of Mr. Rides, of the fish-hatcheries, just been completed. It will be remembered that of 15,000 eggs put in each pair of five sets of boxes, from box to box of which the water rippled and splashed down, the following were the deaths in the egg stage :—

Box No. 1	6,675
„ No. 2	5,232
„ No. 3	4,650
„ No. 4	4,713
„ No. 5	3,252

Thus there hatched in—

Box No. 1	8,325
„ No. 2	9,768
„ No. 3	10,350
„ No. 4	10,287
„ No. 5	11,748

and of these numbers the following developed blue swelling :—

Box No. 1	1,626
„ No. 2	1,269
„ No. 3	1,584
„ No. 4	1,358
„ No. 5	1,557

or the following percentages of the fry which were born. The gas content of the first and last, and the radium-emanation content of the series, is given along with these :—

	Percentage of Fish developing Blue Swelling.	Gas Content.	Radium Emanation.
Box No. 1	19·5	Nitrogen, 16·82 Oxygen, 5·34 Carbon-dioxide, 1·80	126
„ No. 2	13·0	..	111
„ No. 3	15·4	..	95
„ No. 4	13·0	..	83
„ No. 5	13·0	Nitrogen, 15·98 Oxygen, 5·68 Carbon-dioxide, 1·88	69

The acclimatisation authorities assert that the proportion of blue swelling in the top box to that in the bottom is usually much greater than this, and ascribe its comparatively even distribution over the boxes to the fact that, owing to conditions, eggs likely to develop it died before hatching.

In another series of eight boxes arranged so that the water rippled from box to box, the ratio of blue swelling in box 1 to that in box 8 was as 5 to 2. We have no data regarding the gas content or radium-emanation content of this series, but the figures given seem to show that the mortality amongst eggs, the blue swelling, and also the radium-emanation and the nitrogen content, fall off, whilst the amount of oxygen slightly increases.

To throw further light on the first two effects—viz., mortality amongst yearlings, and pop-eye—lots of ten fish were placed in each of the boxes 1, 3, and 4 at the Museum. It was already known that both death and pop-eye occurred in box 2. The result of these experiments was to a certain extent vitiated by the extreme agility with which the fish escaped, even though every care was taken to prevent it. The radium-emanation content was, in the units we have used, as follows:—

Box No. 1	197
„ No. 2	179
„ No. 3	164
„ No. 4	150

The fish were very kindly supplied to us by the Acclimatisation Society. From the reason given, we are unable to supply any exact data as to numbers, but it is unquestionable that both death and pop-eye occur most readily in the boxes nearest the well. Whilst this is so, of 10 fish put into box No. 4 on the 3rd September, 1 died on the 6th September, 1 on the 14th September, and 1 on the 18th September. We have not recorded a case of pop-eye in box No. 4, though it occurred in box No. 3.

The fish dying in these boxes were submitted to Dr. Chilton for examination; and he found clear evidence in some, though not in all, of gas emboli in the gill-filaments, and on pricking the conjunctiva of a fish with pop-eye, two or three bubbles of gas escaped from behind the eye, and the eye resumed its proper and normal position.

An examination of a pool in the Gardens where large numbers of fish were kept in very close confinement for stripping purposes gave the following gas content:—

	C.c. per Litre.
Nitrogen	16·95
Oxygen	4·59
Carbon-dioxide	2·16

Temperature, 12·4 C.

Comparing these figures with box 3 at the Museum, in which on several trials a large number of fish died, and in which one case of pop-eye was developed, it will be seen that less than a cubic centimetre per litre of nitrogen divides the two, and about 0·4 of a cubic centimetre of oxygen, and yet the difference is one of life and death. Whilst this is so, the radium-emanation contents are, in box 3, 164, and in the stripping-pool, 80.

An attempt was made to determine the nature of the gas liberated from behind the eye in a fish suffering from pop-eye, by means of a spectroscopic examination of it, but without certain result. It is hoped to decide the point definitely later on.

The whole question is one for biologists and physiologists rather than for physicists; and the problems suggested to them for discussion are these: (1) Is the difference in the amount of nitrogen sufficient to explain the effects, of which there are four separate ones? (2) Are these effects due to an insufficiency of oxygen? or (3) are the gas emboli in the gill-filaments and the gas behind the eye a secondary effect caused by radium emanation, which is, though present in extremely minute quantities, so extraordinarily active a gas as to be possibly capable of producing the effect if the first two questions should be answered in the negative?

ART. XXIX.—*Petrological Notes on Rocks from the Kermadec Islands; with some Geological Evidence for the Existence of a Subtropical Pacific Continent.*

By R. SPEIGHT, M.A., B.Sc., F.G.S.

[*Read before the Philosophical Institute of Canterbury, 6th October,* 1909.]

WHEN the scientific party visited the Kermadec Islands in the year 1907, Mr. R. B. Oliver, one of its members, made collections of the rocks occurring there, and subsequently submitted them to me for examination. Their field relations will be fully dealt with by him at a later date; but after a microscopical examination of the collection I feel justified in bringing forward at once a matter which, from what he has told me, is altogether apart from his own work, and may have a somewhat important bearing on the biological history of New Zealand. Mr. Oliver, following Mr. Cheeseman,* believes that the Kermadecs are oceanic islands; but there is some evidence that they are built up by volcanic action on the remnants of a former continent which stretched south-west from Fiji and Tonga and probably extended so as to join with northern New Zealand. The Kermadec Islands may be oceanic in a biological sense—viz., that their present fauna and flora are derived from neighbouring lands by the various processes of distribution, and are not a survival of that belonging to a continent of which they once formed part; there are facts, however, which point to a close connection with a continental area, if not recently, certainly in early Tertiary or Mesozoic times.

Mr. Cheeseman's conclusions were come to after a close study of the flora of the group. He maintained that the islands were populated by the transporting agency of birds, winds, and ocean-currents, and that they received the bulk of their plants from New Zealand, a smaller proportion from Polynesia, and that five species were endemic. The occurrence of *Aleurites moluccana*, the well-known candlenut of tropical regions, whose nuts W. H. Guppy showed could not float, is one of the special peculiarities, and would be very strongly suggestive of a continental connection for the group were it not possible that it was introduced by man. Cheeseman, however, does not mention this possibility. Apart from the flora, the existence of an indigenous rat (*Mus exulans*) on Sunday Island, and also its presence in large numbers on Macauley Island when first discovered by Lieutenant Watts, is suggestive of a land connection. The rat is widely distributed in Polynesia, and it is possible that it was introduced on Sunday Island either intentionally or unintentionally by Natives on their long sea-voyages. But Macauley Island is very inaccessible, and it is very improbable that they introduced it here. It must be remembered, however, that this rat, which is the same as the Maori *kiore*, is used as an article of food by the Natives of some islands even when other supplies are plentiful, and also it is so widely distributed in Polynesia that conclusions to be drawn from its distribution are perhaps ill founded. Man has no doubt been responsible for its introduction into many islands.

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* Trans. N.Z. Institute, vol. xx, 1888.

A careful examination of the lower forms of animal life belonging to the Kermadecs will ultimately provide a definite solution to the problem; but our present knowledge is by no means satisfactory, though no doubt when all the collections made by the party are fully worked up much additional information will be available. Mr. H. Suter has furnished me with details concerning the land *Mollusca* of the group, and he concludes that the islands are the meeting-ground for forms belonging both to Polynesia and New Zealand, but that the former preponderated over the latter. The mere presence of land *Mollusca* on an island nearly five hundred miles from other land, notwithstanding the readiness with which they can be transported in the juvenile state, is certainly suggestive of a continental connection. This conclusion is strongly supported by the character of the marine *Mollusca*. The higher percentage of Polynesian forms points to a closer or more recent connection with the islands to the north than with New Zealand; and this fact is borne out by a study of the form of the sea-bottom and the depth of the sea over the area through which communication probably took place. This conclusion is apparently at variance with that arrived at by Mr. Cheeseman.

The peculiarities in distribution of plants and animals in the southern Pacific islands have suggested to several eminent naturalists the probability of the former existence of a continent in that region. They approached the subject from the biological side, without the advantage of the geological knowledge that we now possess. Alfred Russell Wallace says in his "Island Life," "It is possible, too, that there may have been an extension [of New Zealand] northward to the Kermadec Islands, and even further, to the Tonga and Fiji Islands, though this is hardly probable, or we should find more community between their productions and those of New Zealand." Wallace, however, looked to a connection with north-eastern Australia as being most probable. H. O. Forbes* had a similar idea of the existence of a continental area in this region, and included it under the vast continent in the Southern Hemisphere to which he gave the name Antarctica.

Captain Hutton held very strongly to the opinion that New Zealand was connected at one time to a Pacific continent. As early as the year 1872 he advocated the theory, and in his presidential address before the Philosophical Institute of Canterbury, 1883, published in the "New Zealand Journal of Science," 1884, and also in the "Annals and Magazine of Natural History," vol. xiii, 1884, he discussed the matter from a biological standpoint. He said then, "We must suppose that it was during the Upper Jurassic or Lower Cretaceous period that New Zealand was joined to the South Pacific continent, while during the Eocene it extended towards New Caledonia, and again in the Pliocene towards the Kermadecs." The last statement is an inference from the extension of glaciers in New Zealand, which Captain Hutton put in Pliocene times, and attributed to elevation of the land. It seems difficult, however, to account for the absence of glaciation in the North Island if that elevation extended nearly as far north as the Kermadecs; and it seems probable that elevation was only one of the causes of that glaciation.

Later on, in his "Index Faunæ Novæ-Zealandiæ," and again in the year 1905, in a letter to *Nature* (vol. lxxii, page 245), he urged the existence of a tropical and subtropical trans-Pacific continent during Cretaceous and

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* Forbes, H. O.: "Natural Science," vol. iii, 1893.

Eocene times in order to explain peculiarities in animal and plant distribution and the South American relationships of New Zealand forms. He advocated also a continental Antarctic connection in Jurassic times between New Zealand and South America, followed by a connection in the form of islands in Cretaceous times. The importance of the Kermadecs in the former land bridge was thoroughly recognised by Captain Hutton, especially as it is a kind of "half-way house" between New Zealand and the tropical areas immediately to the north-east, and he specially mentions their bearing on the migration of birds between New Zealand and the Polynesian islands. If migrations always take the line of a past or present land connection, either continuous or in the form of islands, the continental origin of the Kermadecs is rendered more probable.

He was supported by Dr. Von Ihering in a paper "On the Ancient Relations between New Zealand and South America" (Trans. N.Z. Inst., vol. xxiv, p. 431). The latter says, "The fauna of East Polynesia has such a well-pronounced Mesozoic character that the supposition of a very old Pacific continent, breaking up in pieces more and more during the Mesozoic era, may give us a very natural explanation." Von Ihering no doubt regarded the connection with America as made through an Antarctic continent, and from this land first the eastern Polynesian islands, then New Zealand, and finally Australia and New Guinea, were separated. With the exception of his disbelief in a "junction" with America in low latitude, his views accord with those of Captain Hutton.

Mr. Hedley, in his various papers* on distribution in the Pacific Islands, controverts Wallace's ideas of a direct connection between New Zealand and northern Australia, and insists on a junction once existing with New Caledonia, the New Hebrides, and New Guinea and New Zealand. The land forming this connection he called the "Melanesian platform." On it he placed Fiji, but not Tonga, Samoa, or the Kermadecs. Mr. Hedley came to this conclusion largely from a consideration of the distribution of the land *Mollusca* of the Pacific; and he regarded the molluscan fauna peopling the lands on his Melanesian platform as derived from an ancient continental fauna, and that on the other islands as a number of waifs and strays. He concluded also that the continent had no connection with America, as no sign of an American immigration can be traced in the central Pacific.

Dr. Pilsbry,† after a consideration of the character of the Polynesian snail fauna, concludes as follows: "The hypothesis of a late Palæozoic or early Mesozoic mid-Pacific continent (upon the sunken heights of which the present island-masses, volcanic or coral, have been superposed) is advanced to account for the constitution of the Pacific snail faunas, which are shown to be (1) nearly homogeneous over vast areas, (2) composed of ancient types with no admixture of the great series of modern families, and not derivable from any Tertiary or modern continental fauna or faunas in the sense that the Atlantic faunas have been derived. The *Mollusca*, land and marine, supply no evidence that the Pacific continent was ever connected with or faunally affected by the American, but emphatically deny such connection."

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* C. Hedley: "Natural Science," vol. iii, 1893; Trans. Roy. Soc. N.S.W., 1895; Proc. Linn. Soc. N.S.W., 1899.

† "Genesis of Mid-Pacific Faunas," by Henry A. Pilsbry, Sc.D., Proc. Acad. Nat. Sci. of Philadelphia, 1900.

The strongest supporter of a trans-Pacific continent is Dr. Baur, of Chicago. He deals with the matter, largely from a biological standpoint, in an extremely important paper on "The Origin of the Galapagos Islands," published in the "American Naturalist," vol. xxxi. After a thorough examination of the distribution of numerous families and genera he concludes that the Pacific islands are the remains of a former Pacific continent; that this continent existed till just before Miocene times.

It is thus very apparent that there is a strong consensus of opinion among leading zoologists that a Pacific continent once existed, the principal disagreement being in the matter of boundaries. While Hedley would restrict it to his Melanesian platform, Pilsbry and probably Von Ihering would extend it as far as Tahiti and the Marquesas, and Hutton and Baur would make it stretch as far as South America.

It is not my intention to discuss further the biological side of this question, but to collate the geological evidence afforded up to the present as to the probability of the existence of such a mass of land. The evidence as to the continental nature of each group of islands over the site of the hypothetical continent will be briefly considered.

KERMADEC ISLANDS.

Owing to their peculiar position half-way between New Zealand and Tonga, the Kermadecs possess a special importance in this matter, so that any geological evidence which they afford is of great value.

A suggested continental connection for them, based on geological evidence, was made by Professor Thomas in his paper "Notes on the Rocks of the Kermadec Islands" (Trans. N.Z. Inst., vol. xx, p. 311, 1888). In describing the specimens collected by Mr. Percy Smith he notes the occurrence of a granite, but suggests that it may have come to the islands in the ballast of some ships. Present results show that this view cannot be accepted. While the main mass of the Kermadecs is composed of volcanic rocks consisting chiefly of augite hypersthene andesites of somewhat acid character, olivine augite andesites of basic character, and acid basalts, there occur in the tuffs on the north side of Sunday Island numerous boulders of hornblende granite. These boulders also occur scattered about the island, and one specimen came from a block situated at a height of 1,600 ft. Professor Thomas's suggestion as to the "ballast" origin of these boulders is therefore untenable, and his first hypothesis of the island forming part of a continental area seems to be perfectly sound. Mr. Oliver did not find the rock in position, but from the occurrence of many fragments it is evident that plutonic rocks must be at a very shallow depth below the volcanic covering, and may even yet be discovered *in situ* in the group. When the small extent of the visible plutonic basement of volcanic islands like the Auckland Islands is considered, it is extremely likely that a mask of volcanic rocks may completely cover a granite foundation of the Kermadecs. But the existence of the fragments in such numbers undoubtedly shows its presence in close proximity. The condition seems very like that which would obtain if the Bounty Islands, which consist of a few granite islets and rocks, only a few feet above the sea, were to become the scene of volcanic activity, and were buried by fragmentary matter and flows of lava. The Bounties contain only one fresh-water alga, and a few low forms of animal life besides the birds and seals which visit them. Should such an island be built up, and become large enough to allow vegetation to flourish, then it would present most of the characters of an oceanic island. Such appears to be the probable position in the case of the Kermadecs. The great difficulty, however, is in coming to any satisfactory conclusion as to the date of their existence as land above sea-level. It is the fact of the occurrence of plutonic acidic rocks in the group that has suggested the consideration of the geological evidence for the existence of a Pacific tropical or subtropical continent, previously demanded on purely biological grounds.

LORD HOWE ISLAND.

Lord Howe Island, according to David and Etheridge,* is composed of volcanic and coral-sand rocks. The former include a series of diabasic basalts which David says are certainly pre-Tertiary, and may be Palæozoic.

NORFOLK ISLAND.

Norfolk Island is largely volcanic, but, judging from the evidence of its fauna and flora, it has undoubtedly been connected with New Zealand.

NEW CALEDONIA.

New Caledonia consists of an ancient series of mica-schists and slates with a general north-easterly strike. Limestones are interstratified with the slates. Besides this is a great series of serpentines and serpentine schists with beds of chrome and nickel, and associated with it are beds of melaphyre and tuffs overlaid by altered sedimentaries and shales with fossils identical with those of the New Zealand Trias. The Triassic zone strikes north-west and south-east parallel to the general trend of the island, and is followed by beds of coal of Jurassic age. It is probable that the serpentines are of later date than the coal-beds. The association of beds of serpentine with Triassic sedimentaries near Nelson in New Zealand, containing identical fossils, is suggestive of a common origin, though it may be a mere coincidence. These beds prove that continental conditions have existed in New Caledonia or its immediate neighbourhood for long periods of time.

NEW HEBRIDES.

Gneisses, crystalline limestones, and serpentines like those in New Caledonia are reported from some of the islands of this group. However, according to Mawson,† the New Hebrides are composed of andesitic conglomerates with overlying beds of Miocene age consisting of foraminiferous submarine tuffs and limestones. These were folded up and formed into a mountain-chain of the alpine type, with a general west-north-west trend. Associated with this were extensive faults, and volcanic eruptions along the line of faulting. Over the folded Miocene series submarine tufaceous beds were laid down, containing at times numerous *Foraminifera*. These are covered with a thin veneer of coral rock, rising in terraces to a height of over 2,000 ft. The New Hebrides are therefore of recent appearance in their present subaerial form, though biological evidence is in favour of a continuous land connection. In a footnote to his paper Mr. Mawson says, "It is none the less probable that limited outcrops [of beds older than Miocene] do occur, as from the advanced metamorphism state of the pebbles of uralitic porphyry from Malekula they must date back to times preceding the folding."

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* "Lord Howe Island": Memoirs Aust. Museum, No. 2.

† Proc. Linn. Soc. N.S.W., vol. xxx, 1905.

The Solomon Islands, according to Guppy, contain quartzites and schists.

FIJI.

The first geological evidence of the continental origin of Fiji was supplied by Wichmann in 1883. He worked up the material collected in 1876–78 by Kleinschmidt and Gräffe from Viti Levu and other islands of the group. This included crystalline schists, granular limestone, granite, diorite, gabbro, found partially *in situ* but partially in river-deposits. Wichmann remarks, "No older massive rocks or sedimentary strata are known from the other 'volcanic' groups of islands of the Pacific Ocean (excepting Pelew, Solomon Islands, New Caledonia, Marquesas Islands). On some of them—for example, the Galapagos, or Sandwich Islands—it seems really to be made out that they have been built up by younger and recent volcanic masses. There is a possibility, and even a probability, however, that older formations served as a fundament, the examination of which is prevented by the extensive covering."* These remarks seem to apply in the case of the Kermadecs.

W. H. Guppy, in his book entitled "The Naturalist in the Pacific," discussed the question, but he approached the subject with a mind apparently made up in the contrary direction, and he denied that Fiji ever formed part of a continent. He maintained that the islands were entirely volcanic, or composed of marine tuffs now elevated above the sea. Although he found plutonic rocks in Vanua Levu, he attached no importance to the fact, and was evidently unaware of Wichmann's discoveries.

Any doubt as to the continental character of Fiji was set at rest by the work of Dr. Woolnough. He published his first paper on the subject in the Proceedings of the Linnæan Society of New South Wales in 1904, and confirmed his first results by subsequent examination of Viti Levu, publishing an account of his work in the same journal in the year 1907. On both occasions he found in the interior of Viti Levu *in situ* large developments of gneisses, schists, granite, slates, and other metamorphosed rocks of undoubtedly great age. A series of specimens sent to the present author from the northern unvisited part of the island contains large fragments of quartz (evidently derived from veins in sedimentary rock), fragments of hornblende diorite from a tuff or conglomerate, as well as trachytes, andesites, and basalts. Among the collection is a rolled fragment of nephrite which was picked up in a creek on the north of the island east of Ba. I view this specimen with a certain amount of suspicion, as it may have been brought there by man and dropped in the creek; but it nevertheless may be derived from a solid mass of the stone in position—a possibility by no means remote, seeing the development of allied rocks in the neighbouring island of New Caledonia.

Although the continental character of Fiji is certain, yet it shows evidence of a recent elevation. However, the island of Kandavu, about fifty miles south of Suva, has undoubtedly been a part of the mainland, judging from its fauna and flora, yet it is separated from the mainland of Fiji by over

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* Quoted in Dr. Baur's paper, *loc. cit.*

1,000 fathoms of water—in fact, by a greater depth than separates Fiji from Tonga.

Now, this island is looked upon as an integral part of Fiji, and not populated by haphazard means. If this is the case, there has been either a local sinking of a block of the crust between Kandavu and Viti Levu, or there has been a general depression of the whole area. If Kandavu were united by land to Fiji, and severed as the result of such a general sinking, then it is highly likely that Tonga also was connected with a land bridge by a somewhat circuitous route in a southerly direction, following a submerged ridge which runs nearly to the Kermadecs, on which the water does not exceed 1,000 fathoms. Granting such an elevation, a deep, narrow gulf would extend towards the south between Fiji and Tonga. However, arguments resting purely on ocean deeps are very unreliable, as local upwarpings and downwarpings, as well as settling of earth-blocks, are known to occur of such a magnitude as would account for all the facts without any general alteration of large areas of the earth's crust; and we have the case of Krakatoa, showing how an isolated island near a coast-line may be peopled rapidly by winds, ocean-currents, and birds.

TONGA.

In 1891, in a paper on the Tonga Islands read before the Geological Society of London, Lister mentions the occurrence of fragments of garnet, tourmaline, and uralitic gabbro in tuffs of the Eua Island, toward the southern end of the group. No plutonic rocks were found *in situ*, but the occurrence of garnet and tourmaline suggests the close proximity of an area of metamorphic rocks. In his criticism of that paper, J. W. Gregory mentions the occurrence in the Marquesas Islands of granites and gneisses, and also the fact that these islands have a biological connection with both Malaysia and Chili. I cannot find any authority in the literature at my disposal for Gregory's statement, except that of Marcou, mentioned in Wallace's " Island Life."

In Jensen's paper on the geology of Samoa* reference is made to the Tonga Islands. This author concludes that they lie on a fold of the earth's crust, with a fault running parallel to them on the western side: " The islands are probably situated over continental rocks on an old shore-line " ; and " that the ridge is probably a structural feature and not the effect of vulcanism." The eastern shore of the area would be determined by the Tongan trough, which lies immediately to the east of the islands.

If we consider the position of the Kermadecs with regard to Tonga, and note the similarity in situation, just to the west of profound ocean troughs in direct alignment, and note also the connecting-ridge between the two groups as revealed by soundings, then the probability of a similar origin for both groups should impress us strongly. The Kermadecs would lie on the south-westerly extension of the old Tongan shore-line, and the volcanic action in the southern group would be only a counterpart of that in the northern group—that is, it would be only a secondary phenomenon resulting from great earth-movements in the region.

SAMOA.

These islands, according to Jensen, are entirely of volcanic origin.

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* Proc. Linn. Soc. N.S.W., vol. xxxi, 1906.

TAHITI.

In 1904 Lacroix* described from Tahiti a series of plutonic rocks, embracing gabbros, monzonites of alkaline affinities, as well as true nephelene syenites; but these may be the plutonic or hypabyssal equivalents of the volcanic phonolites or nephelinites of the region.

The other islands, as far as is known, are of volcanic origin, or are composed of limestones. The occurrence of volcanic cones is not really opposed to the existence of a former continent, as they may be the unsubmerged peaks of the mountains which formerly covered its surface. However, many of the volcanoes in the area are in process of construction, and have had a submarine beginning—in fact, in some localities they have got no further, and have not yet succeeded in establishing themselves in a subaerial condition. These areas appear to be those where the crust of the earth is rising, a special case being the line of volcanic vents parallel to the general direction of the Tonga Islands, which undoubtedly show traces of recent elevation.

Thus, over a large area of the mid-Pacific region, and particularly that part where Darwin demanded a sinking land to explain the formation of coral reefs and atolls, there appears to be evidence of the former extension of continental conditions, deduced from geological considerations. The sinking crust practically implies a former continent. As the boring at Funafuti proved absolutely that the crust had been depressed relative to sea-level in that locality by at least 1,100 ft., so we may suppose that sinking has gone on in other places where there are coral islands of similar structure. The fact of a recent elevation being known in numerous cases over the same area does not dispose of the hypothesis of a general and prolonged subsidence preceding this local elevation, and indeed it draws attention to the instability of the crust in that region. If subsidence has gone on to the extent required by Darwin it would rapidly submerge any continent, and leave little trace behind except that which chance geological discoveries and a close study of the fauna and flora would reveal.

An examination of the bathymetric map of the south-western Pacific, modified by recent surveys, discloses certain well-marked submarine physical features which suggest the lines of connection with the former Pacific continent. These may be easily followed if we suppose the whole area to be raised stage by stage till it is above sea-level. Imagine, first of all, the elevation to take place till the 1,000-fathom line is exposed. We should then have a ridge extending north-west from New Zealand towards the mid-eastern coast of Queensland. Lord Howe Island would rise as a mountain on its extreme western edge, and Norfolk Island would be a similar mountain on its eastern edge. Sea would separate it completely from Australia, which coast it would approach most nearly in the neighbourhood of Rockhampton. New Caledonia would still be separated.

To the north-east the coast of New Zealand would be extended somewhat, but a long narrow ridge embracing the Kermadecs would follow the general north-eastern trend of the islands, and would approach, but not junction with, a similar ridge on which the Tonga Group would lie. A long tongue of land would stretch down from the Fiji Islands and junction with the Tongan ridge. A deep gulf would run to the south-west between Fiji and

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* "Comptes Rendus," 1904.

Tonga, and a sea of triangular shape would be included between the north east and north-west ridges. A few islands would dot the fringes of this sea.

The land connection, here established in part, would be the line of communication between New Zealand, Norfolk Island, Lord Howe Island, New Caledonia, and northern Australia on the one hand, and between the Kermadecs, Fiji, and Tonga on the other; but as yet the continental areas to the north, embracing northern Queensland, New Caledonia, and Fiji, would be separated by narrow straits. A deep sea would lie to the east of the Kermadecs and Tonga, and a similar one on the south-west of Lord Howe Island, between it and the coast of New South Wales and south-eastern Queensland.

If now we imagine the sea-bed raised another 1,000 fathoms, the north-westerly ridge would be joined on to northern Queensland, but would still be separated nearly as much as ever from the east coast of Australia. New Caledonia, the New Hebrides, Fiji, and Tonga would all be completely linked with New Zealand. Samoa would remain separate. Immediately north of New Zealand would be an inland sea rudely square in outline; south-west of New Caledonia would be a long narrow depression filled with water, running parallel to the direction of New Caledonia, and there would be a similar depression, but deeper, between it and the New Hebrides. Very deep sea, over 3,000 fathoms, would still lie east of the Kermadecs and Tonga. The land embraced at this stage probably represents roughly the extent and form of the tropical and subtropical Pacific continent, though no doubt recent warpings up and down of the earth's crust and local elevations and depressions would modify it somewhat. It will show a certain regularity in the arrangement of its physical features. The general structure will exhibit north-westerly and south-easterly trend-lines in the part to the west and north of New Zealand. The New Zealand ridge, the lines of New Caledonia, New Hebrides, Loyalty Islands, the depression and troughs between them, even certain indentations of the coast-line and valleys, would show the general orientation. This would seem to be parallel with certain lines of folding at present shown by some of the older rock-systems of New Zealand; but the identity is probably a mere coincidence, as the structural features spoken of as existing in the restored continent are in all probability of much later date.

If, however, we pass to the eastern side of the continent, the trend-lines are found to run in a north-easterly and south-westerly direction. The Tonga Group, the Kermadecs and their connections, the Kermadec trough and Tongan trough exhibit this to a remarkable degree. Their line is that of the main folding exhibited in the mountain-structure of New Zealand, and much more recent than the old north-westerly folding. At the ends of the north-easterly-running physical features there seems to be a tendency to turn north and north-west, so that the two main directions may be part and parcel of the same great crustal movement.

These, then, would be the main structural features of this restored continent, if it is possible to rely on the evidence afforded by the present form of the sea-bottom. Now, does the geological evidence afford any indication of the age of the hypothetical continent? The Kermadec Islands apparently furnish none, except that some time or other the granite rock no doubt formed a land-surface. The same remarks apply to all the eastern islands of Polynesia. Although Fiji is continental, yet its history is uncertain.

Dr. Woolnough says, "The rocks of Fiji consist of two main groups: the first of these includes continental rocks of high but undetermined geological antiquity; the second includes Tertiary to Recent formations of volcanic and sedimentary origin. Between these two is an enormous hiatus." This admits of three explanations:—

(1.) The area may have been one of prolonged and continuous subsidence since very early geological time, and the land may have been gradually decreasing in size, with an elevation of nearly 1,300 ft. since Tertiary time.

(2.) The land may have been one of continual elevation, denudation keeping pace with uplift, so that no trace is left.

(3.) A third, that land was in existence in Palæozoic and Mesozoic times, and then followed a subsidence, during which the Tertiaries were laid down, and then there was an elevation.

These three hypotheses are thus stated by Dr. Woolnough. He inclines to the first, whereas Wichmann believed in the last. Wichmann's theory apparently explains the biological facts as demanded by Hutton, Pilsbry, Hedley, Von Ihering, and Baur. It is possible that the Tertiary subsidence extended all over the south-western Pacific, and the recent elevation of Fiji has its counterpart in the recent elevation of the Kermadecs and Tonga. If this is so, the Kermadecs were cut off from Fiji in early Tertiary times, and rose at a later date, with probable periods of oscillation, either as a volcanic cone from a shallow sea or as a cone on a small area of plutonic rock which is now covered with a veneer of volcanic fragmentary material and lava-flows.

Further to the westward the presence of Triassic and Jurassic sedimentaries in New Caledonia is proof that shallow-water conditions extended over a large part of the area in Mesozoic times, with the implied presence of a land-mass in the neighbourhood of such a size that thick and extensive sediments could be derived from it.

The suggestion of a continental origin for the Kermadec Islands appears to be following the present tendency to reduce the number of oceanic islands. It is highly probable that many volcanic islands classified as oceanic will ultimately have to be looked on as built up on the remnants of a continental area. When we consider that the Galapagos Group—thought to be typically oceanic by Wallace and Darwin, although the latter had doubts about it—has been proved lately by Baur and Hemsley to be certainly of continental origin on biological grounds, the case of the Kermadecs, stated so decidedly by Cheeseman and Percy Smith, is perhaps open to revision. If their claims to be classified as continental are worthy of serious consideration (which indeed I think is the case), then they, with the volcanic Norfolk Island and Lord Howe Island, would form the northern outlier of the New Zealand continent, just as the Snares, Auckland Islands, Campbell Islands, Bounty Islands, Antipodes Islands, and Macquarie Islands form its southern outliers.

PETROLOGY OF THE KERMADEC ISLANDS.

The only previous reports on the rocks of the Kermadec Islands are those of Professor Thomas (Trans. N.Z. Inst., vol. xx, p. 311, 1888) and of the present author (Trans. N.Z. Inst., vol. xxviii, p. 625, 1896). The former reports the occurrence in the group of basalt, augite andesite, pitchstone, obsidian, as well as of a hornblende granite; and the latter mentions augite andesites and also a tachylyte. With the exception of the granite, all the rocks are volcanic. The present collection no doubt contains some of those previously described, as neither Professor Thomas nor myself has visited the group, and the exact locality and position of the specimens are somewhat doubtful. I have classified these rocks into plutonic, dyke rocks, lava-flows, and fragmentary deposits, without any regard to their age relative to each other.

Plutonic Rocks.

Hornblende granite occurs as boulders in tuff or scattered on the surface of the island. One block was found at an altitude of 1,600 ft. In the hand-specimen this is a whitish even-grained rock, with light-coloured green hornblendes of small size visible, as well as feldspar and a little quartz. The specific gravity is 2·63. Under the microscope it is found to consist of feldspar, both orthoclase and plagioclase (albite), the latter in large amount; quartz, irregularly distributed, full of liquid and gas bubbles; epidote, frequently developed along the cleavage-planes of feldspar; apatite, in grains and short needles; and also titanite, which sometimes adopts the wedge-shaped form so frequently characteristic of the mineral, and at others occurs in aggregates. Neither biotite nor muscovite is present. From the general character the rock shows a close relationship to a syenite, although containing quartz. This rock appears to be similar to that described previously by Professor Thomas.

Dyke Rocks.

These rocks are found on the summit of Meyer Island and, as intrusions, on the coast of Sunday Island.

No. 8. Augite Andesite.—From a dyke on Meyer Island.

In the hand-specimen this is a vesicular, dark-grey rock with prominent feldspar phenocrysts; its specific gravity is 2·56. It is an augite andesite of the most acid type of the volcanic rocks examined. This is apparently the rock described by Thomas in the "Transactions of the New Zealand Institute," vol. xx, page 313.

It is the only specimen received from the series of dykes mentioned by Percy Smith (Trans. N.Z. Inst., vol. xx, p. 339) as intersecting Meyer Island.

No. 29. Augite Andesite.—From a small sill or intrusion at Hutchinson Bluff, Sunday Island.

Macroscopic.—A fine-grained dark rock, slightly vesicular, containing very small phenocrysts of feldspar. Specific gravity, 2·63.

Microscopic.—The groundmass is fine-grained, contains much glass in patches, with grains of magnetite and augite, and microlites of labradorite; there are very occasional phenocrysts of labradorite and augite.

No. 30. Augite Andesite.—Occurs as an intrusion in tuffs on the north coast of Sunday Island.

This specimen is similar to No. 29, but is coarser in texture, and contains much magnetite in grains.

No. 40. Andesitic Basalt.—Occurs as a dyke in Scenery Bay, south coast of Sunday Island.

Macroscopic.—A grey rock, with prominent feldspar phenocrysts and occasional olivines and augites. Specific gravity, 2·93.

Microscopic.—The groundmass is composed of grains of augite and olivines and plagioclase laths. In some parts there is a good deal of glass, in others the rock is almost holocrystalline. The phenocrysts are of large fresh olivines, augite, basic labradorite, with grains of magnetite. The groundmass of this rock is distinctly basaltic in character, but the numerous feldspar phenocrysts give it an andesitic character. The same remark applies to other specimens.

Lava-flows.

No. 2. **Andesitic Pitchstone.**—From a boulder at base of cliffs, Fleetwood Bluff, Sunday Island.

Macroscopic.—A rock dark in colour with pitchy lustre.

Microscopic.—The groundmass consists of glass, fairly clear in some parts, crystallitic in others, perlitic, with well-marked flow structure. The phenocrysts are of sanidine, plagioclase (acid labradorite), strongly pleochroic hypersthene, and occasional augites.

No. 9. **Andesite.**—From lava-stream on Moumoukai, Sunday Island.

Macroscopic.—A dark-grey rock, vesicular with small phenocrysts of feldspar. Specific gravity, 2·44.

Microscopic.—Groundmass of feldspar laths (labradorite), augite grains, a good deal of glass in patches. The phenocrysts are of medium labradorite; no others were observed.

No. 21. **Andesite.**—From lava-stream, Denham Bay, Sunday Island.

Macroscopic.—A very dark compact rock, with very occasional small phenocrysts of feldspar showing. Specific gravity, 2·89.

Microscopic.—Groundmass composed of feldspar microlites, augite and magnetite grains, with patches of clear coloured glass. Very occasional small phenocrysts of feldspar and augite are visible.

No. 26. **Augite Olivine Andesite.**—From lava-flow, south end of Denham Bay, Sunday Island.

Macroscopic.—Dark-coloured fairly compact rock. Specific gravity, 2·80.

Microscopic.—Groundmass composed of feldspar laths and augite grains, ophitic in places, with a good deal of glass, and numerous grains of magnetite. The phenocrysts are of feldspar (basic labradorite), occasional augites, and rare olivines.

No. 34. **Olivine Andesite.**—From lava-stream west of Blue Lake, Sunday Island.

Macroscopic.—A grey rock, vesicular, with numerous feldspar phenocrysts. Specific gravity, 2·76.

Microscopic.—Groundmass consists of numerous augite feldspar microlites, simple and twinned grains of augite and olivine, and occasional patches of glass, with grains of magnetite. The phenocrysts are of basic labradorite, with numerous gas-inclusions, small phenocrysts of partly serpentinised olivines, and occasional slightly pleochroic augites. This rock resembles somewhat the olivine andesite of Banks Peninsula.

No. 36. **Basalt.**—From lava-stream, east coast of Sunday Island, overlying tuffs.

Macroscopic.—A dark-grey rock full of small vesicles. Specific gravity, 2·84.

Microscopic.—Groundmass of numerous grains of magnetite, smaller feldspar laths untwinned and twinned (labradorite), grains of olivine, and occasional patches of glass. The phenocrysts are of basic labradorite, augite crystals, and frequent grains of olivine stained with iron-oxides.

No. 37. **Basalt.**—From lava-flow behind Denham Bay, Sunday Island.

Macroscopic.—A grey rock, vesicular, with numerous phenocrysts of feldspar. Specific gravity, 2·82.

Microscopic.—Groundmass of augite grains and plagioclase microlites, showing well-marked fluxion structure. The phenocrysts are of labradorite, olivine in rounded grains, partially serpentinised with seams of limonite. Grains of magnetite are very common. A more basic rock than No. 36.

No. 38. **Andesitic Basalt.**—From lava-flow, south end of Denham Bay, Sunday Island.

Macroscopic.—Greyish rock, with prominent feldspar phenocrysts. Specific gravity, 2·86.

Microscopic.—Groundmass containing much augite, grains of olivine, feldspar laths. Subophitic in texture. The phenocrysts are of basic labradorite, irregular grains of olivine and augite. There are large grains of titaniferous magnetite in irregular forms. The feldspar phenocrysts are very numerous.

No. 39. **Andesitic Basalt.**—From lava-flow, north end of Denham Bay, Sunday Island.

Macroscopic.—Grey rock, with small phenocrysts of feldspar. Specific gravity, 2·87.

Microscopic.—Groundmass of augite grains, feldspar laths, and grains of olivine, also occasional colourless glass. The phenocrysts are of basic labradorite with numerous glass inclusions, clear grains of olivine, and small augites. Very similar to No. 38.

No. 41. **Andesitic Basalt.**—From lava-flow at sea-level, Scenery Bay, Sunday Island.

Macroscopic.—Dark-grey rock, very vesicular, with numerous feldspars showing. Specific gravity, 2·81.

Microscopic.—The groundmass is holocrystalline, of augite and magnetite grains, and feldspar microlites. There are numerous feldspar and olivine phenocrysts, the latter fresh or but slightly stained with limonite; occasional augites are present.

No. 42. **Basalt.**—From lava-flow under tuffs, Macauley Island.

Macroscopic.—Dark-grey rock, vesicular, with numerous feldspars showing. Specific gravity, 2·55.

Microscopic.—Groundmass of feldspar laths, many grains of olivine, augite, and magnetite. The phenocrysts are of basic labradorite, olivine in irregular grains, seamed with limonite and occasional augite.

No. 43. **Andesitic Pumice.**—From pumice tuffs, Macauley Island.

This is evidently the scoriaceous equivalent of the andesite lavas, as it contains numerous fragments of plagioclase feldspar and augite similar to those occurring in the lavas.

No. 46. **Olivine Andesite.**—Fragment from L'Espérance or French Rock.

Macroscopic.—A dark-grey vesicular rock, with small feldspar phenocrysts showing. Specific gravity, 2·68.

Microscopic.—Groundmass coarse-grained, principally of feldspar (labradorite) laths, grains of augite, and much secondary titaniferous magnetite. There are phenocrysts of labradorite, olivine, and augite, the first-named being very numerous.

Pyroclastic Rocks.

Besides the foregoing, a number of specimens of fragmentary volcanic matter were in the collection. These vary somewhat in character. Nos. 22 and 25, from Boat Cove, Sunday Island, are composed of fragments of andesitic pitchstone and ordinary andesite cemented by a calcareous base and volcanic ash. This contains numerous fragments of reef-building coral. This occurrence seems best explained by a submarine explosion, where the overlying volcanic rocks with their veneer of coral were shattered into fragments and subsequently consolidated, perhaps below sea-level. No. 32 is from a fine-grained tuff on Sunday Island, composed principally of angular fragments of feldspar and augite grains. In this were rounded bombs of blown glass, full of crystallites, and containing fragments of augite and feldspar. Nos. 5, 10, 18, 20, from the small islands north-east of Sunday Island, and Nos. 13 and 14, from Sunday Island, the latter being undoubtedly submarine, are specimens of tuff beds which show the same origin, and are andesitic in character, as they contain numerous fragments of augite and plagioclase feldspar.

The collection also contains sulphur and siliceous sinter from Curtis Island, specimens of volcanic mud from the crater on Sunday Island, and calcite incrustations from Dayrell Islet, Sunday Island.

A general conspectus of the collection shows that the islands are built up of volcanic materials which are andesitic or basaltic in origin, and that acidic rocks form no part of them. The andesites have in general a strong affinity to the basalts, and are sometimes characterized by the presence of olivine and by a groundmass which is basaltic in character; but the numerous phenocrysts of feldspar, and the small number of those of augite or olivine, demands that the rocks be classified with the andesites. Instances of intermediate varieties between andesites and basalts are very common.

The general facies of the specimens does not show any marked resemblance either to New Zealand types or to the specimens I have in my possession from Tofua and Savaii. The presence of hypersthene in some suggests a connection with the Ruapehu - Tongariro - White Island line, the rocks of which are characteristically hypersthene-bearing, as indeed are so many of the andesites of New Zealand—*e.g.*, those from the Clent Hills in the South Island, as well as those from numerous localities in the North Island (see Marshall, "Distribution of Volcanic Rocks in the North Island," Trans. N.Z. Inst., vol. xl, p. 79). The presence of olivine in the andesites is also reminiscent of the later flows from Ruapehu, but suggests much more strongly the olivine-bearing andesites of Banks Peninsula. This type, however, seems to occur in other parts of the south-central Pacific area.

ART. XXX.—*Notes on the Geology of the West Coast Sounds.*

By R. SPEIGHT, M.A., B.Sc., F.G.S.

[*Read before the Philosophical Institute of Canterbury, 1st December,* 1909.]

THE following notes are based on observations and collections made during a fortnight's steamer-cruise in the Sounds in the summer of 1908–9. On that occasion all the Sounds were visited, but the time was too short to do more than collect specimens on the shore where landings were made. However, some of these places have not been previously visited by a geologist. The vast extent of country, the difficulty of travelling on its forest-clad and precipitous slopes, and the small number of accessible outcrops of rock on the shore-line of its deep, wall-sided fiords, render a satisfactory account of its intricate geological structure absolutely impossible at present. It furnishes perhaps the most complex of all the problems that New Zealand geologists will have to solve.

Sir James Hector (4, 5, 6) and Captain Hutton (8) have already given a general description of the country, and Andrews (1, 2) has traced out the evolution of its landscape in the light of modern physiography, an account which has been generally indorsed by Marshall (14). Petrological notes have been furnished by Hutton (9, 10, 11, 12), based on a few specimens collected by himself at various times; and more extended descriptions have been made by Marshall (13, 14) as a result of collections made by him during various excursions into the region. He has drawn special attention to the magnesian rocks at Anita Bay (13), where he discovered dunite, and harzburgite, and olivine-bearing marble whose origin he ascribed to modifications in the neighbouring harzburgite, a conclusion which he based on the evidence of a series of specimens showing transitions between the two rocks. These rocks have been more recently referred to by Finlayson in an interesting paper on the origin of nephrite, read before the Geological Society (3). The present paper has been contributed in order to supplement previous articles. The author has to express his great indebtedness to Dr. Marshall for the loan of a selection of microscopic sections of rocks described by him in his papers. It has thus been possible to identify some specimens here mentioned as being the same as described by Dr. Marshall, or slight variations from them.

In order to give a general idea of the petrology of the area, each locality visited will be taken in turn, and a short description will be given of the rocks collected. It is impossible at present to give any account of their field relations. The notes given are therefore unsatisfactory; but the mere indication that certain rocks occur in particular localities is considered by the author to be of some importance, considering the extent of the area, and the ignorance that at present exists regarding its geological structure.

Before dealing with the petrology of the area, brief reference will be made to one or two points of physiographical interest. The first of these deals with certain shore-features. Even at the heads of the Sounds the shoaling caused by the detritus poured in by large streams is limited to the area close to their mouths. Extensive flats do occur, but they present extremely steep faces to the sea beneath water-level. At the head of Wet Jacket Arm, on sounding to get an anchorage on one of these flats, the depth was one fathom under the bow of a small steamer of eighty tons, and thirteen under her stern. There are no strong currents or tides in the remote recesses of the Sounds to sweep away detritus far from the river-mouth, so the angle of repose is extremely steep. Very fine particles must be carried some distance, as dredgings show that the floors of the Sounds are almost invariably composed of mud. In some cases, such as at the head of Milford, shoaling is very rapid over the area of deposition: at one place, where twenty years ago a depth of fourteen fathoms was recorded, mud-flats covered with driftwood, and exposed at half-tide, now exist. Apart from these, the beaches in process of formation are of extremely limited extent, and if subjected to subaerial erosion would last but a short space of time. Their absence at higher levels, noted by Hector, is therefore no proof that the land did not suffer a depression with subsequent elevation. Captain Hutton noted marine-cut terraces in certain places, particularly at the entrance to Doubtful Sound on Secretary Island, and they are very well marked near Puysegur Point, in the south-west of the area, so that it is probable that a submergence took place, probably posterior to the glaciation; but the question does not seem to be connected in any way with the cause of that glaciation.

The main landscape-forms of this area, as has already been pointed out by Andrews (1, 2), are produced by the modifying effect of glaciation on a well-developed stream-valley system. His conclusions can in general be heartily indorsed. There are, however, one or two features which may be further noticed. The first of these is the general orientation of the main valleys. Although small valleys can be found running in all directions, the general disposition of the main valleys seems to depend on some general underlying cause. An examination of the map shows that the main arms of the Sounds, and the lakes on the eastern border of the region, usually lie parallel to two main directions, one running north-west and the other south-west, thus cutting one another at right angles. This arrangement is difficult to explain in the light of our present knowledge, but it is possible that the formation of the valleys was dependent in the first case on lines of crust-fracture, that the arms grew along these lines, and, in spite of valley-forms being modified, the main directions were always preserved. The smaller valleys running in irregular directions would be subsequent, and determined largely, if not altogether, by the way in which streams eroded the surface. It has been pointed out by J. W. Gregory that fiords are found on the margins of fractured earth-blocks, and it is extremely likely that this is the case here, although there is no positive evidence of their presence. There seems, however, to be considerable difficulty in explaining the origin of the submarine valley of Wet Jacket Arm, and the narrow Acheron Passage, running for miles behind Resolution Island, and almost exactly at right angles to the Arm. The passage is deep throughout its whole length according to the soundings on present charts, and there is little rounding of the corners where it joins with Wet Jacket Arm. The soundings do not reveal that it has been formed by the degradation of a divide by ice erosion. It can be most easily explained as being the result of a cross-fracture. Similar valleys on a less pronounced scale are found connecting Daggs Sound with Doubtful Sound, though it is possible that these may result from the destruction of a ridge by stream and glacier action.

It seems fairly certain that on the east side of the area an enormous fault with a downthrow to the east or an upthrow to the west follows the line of the Waiau River and the east side of Lake Te Anau, and may be prolonged down the Hollyford River. If there is anything in the idea that the general orientation of the valleys depends on fracture-lines, it may have been associated with the movement of the earth's crust. The general even contour of the coast-line on the west and south of the area is reminiscent of southern Norway, and may be the result of fracture, and the settling of an area in the ocean-floor. This has been referred to previously by the present author in a short paper on a "Hornblende-andesite from the Solanders."*

The other explanation of the orientation is that the valleys were originally consequent on the shape of a former land-surface. This would result if the land to the west of Lake Te Anau had been raised in the form of an oval ridge with its chief axis running north-east and south-west. The first drainage-lines established would then be north-west and south-east, across the general strike of the beds, which have a general north-westerly dip. Subsequent streams would take a line approximately at right angles, or parallel to the strike, and, by the processes of absorbing neighbours and extension of their basins, might become the most important drainage-directions. This may, perhaps, be a more satisfactory explanation than that depending on fracture, and it is possible, of course, that both causes may have been present. But if the valley-directions depend on fracture-lines they must date from a time anterior to the glaciation, and cannot be intimately connected with movements that are subsequent to it.

The most interesting physiographical questions are those connected with the results of glacier erosion. That glaciers do erode their beds deeply seems almost certain when the landscape-forms of the region are considered, and the present author agrees with Sir James Hector when he attributes most of the peculiar features to the overdeepening of the main valleys by powerful glacier erosion, as compared with the feebler erosion that went on in tributary valleys when glaciers were smaller. This will explain the hanging valleys, the waterfalls, the truncated and semi-truncated spurs, the alignment of the valley-walls, and the U-shaped cross-section and the longitudinal section of the Sounds, as well as the rock-bound lake-basins—*i.e.*, the pot-holes of a glacier stream, quite analogous to the pot-holes of a river. These points have been fully dealt with by Andrews (1, 2).

The formation of lake-basins by scouring action analogous to the pot-holes of a river must result in some cases. It seems hard to explain the formation of the small rock-bound lakes at the head of George Sound on any other assumption. A striking illustration of the efficacy of this action is furnished by the Rakaia River, in Canterbury. A great glacier flowed down the valley, and part turned at right angles over a low saddle in the direction of Lake Heron. At the point of turning is a well-marked truncated spur with semi-detached knob, and below it a basin nearly half a mile across, smoothed and rounded on the inside, the direction of scouring being clearly circular and horizontal. This was evidently a whirlpool in the ice stream, formed at just such a place as that at which a whirlpool would form in a river, and no doubt formed in an analogous way. This is a peculiar case, which I shall deal with more fully in a subsequent paper, but it illustrates the power of erosion possessed by glacier-ice. It seems likely that many small rock-bound lakes in glaciated country, especially those at lower levels, may arise in this way.

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* Trans. N.Z. Inst., vol. xli, p. 52.

Judging from the shape of the floors of the Sounds, from their constricted and shallow entrances, with, in certain cases, shallower water in the open sea, it seems certain that glaciers have enormous power of excavation. It is possible that more exact soundings may show a continuance of some of the valleys seaward across the submarine shelf. Depths exceeding 300 fathoms are found immediately off the entrance to some of the Sounds on a sea-floor which averages less than 100 fathoms deep. It seems hardly necessary, however, to postulate enormous thicknesses of ice to perform the work. Because ice-action is seen on the sides of an ice-eroded valley high up above its floor, it no more proves that ice filled the valley up to that level than high river-terraces prove that the river formerly filled the valley from its present channel up to those levels. Ice has power to produce rock-cut terraces which are analogous to stream-cut terraces of primary excavation (I have seen instances in the glaciers of the Southern Alps), and many of the signs of glacier-ice high above present valley-floors are relics of the action of the ice streams when they ran at a higher level. The evidence for the existence of glaciers five and six thousand feet thick sometimes demanded in such cases as this seems to me to be very weak, and such enormous thicknesses are quite unnecessary in order to produce the results achieved.

There are one or two land-forms, however, which result from glacier erosion of a former well-developed valley which I do not remember to have seen noticed previously. The first is the special shape of the ends of truncated spurs. These are almost invariably cut off, and reduced to a facet. The uniformity and regularity of this shape is striking. This can be seen very well indeed in the broader Sounds, where the pre-glacial valley-sides were not so steep, were more regular, and where the planing action of the ice was not so intense. The phenomenon is almost absent in Milford. I have seen it well marked in some of the valleys of Canterbury, where the pre-glacial drainage system was more mature. The spur sometimes shows that truncation was repeated, and that, after one strip had been planed off, another one was begun, and a shelf or terrace left half-way up the facet. These faceted spurs seem to be stable landscape forms, and persist when other signs of glaciation are disappearing. They do not receive any drainage except that which falls directly on their surface, and from their even nature it is long before streams establish themselves on them. When streams do, they are usually straight, and take the most direct course downhill, and for this reason they are numerous and small. All this tends to perpetuate the original form of the facet. These truncated spurs are formed in a moderately mature drainage system where the lateral spurs are not strongly developed, and the axis of the valley is tolerably straight. When the direction of the valley is subject to marked variations, and turns through an angle approaching a right angle, then the ice overrides the spur. If the angle turned is greater than a right angle, the action is still more marked, and crouching-lion forms ensue. One feature resulting from this action is that of a rounded hill lying off the end of a spur. This has been moulded by the erosive action, which is more marked near the valley-wall, so that a deep notch is sometimes formed behind the knob. Some of the isolated rounded hills and rocks found in glaciated countries may arise in this way, but many must result from the destruction of longitudinal spurs dividing adjacent subparallel valleys. Transitional forms in all states of development can be seen in the mountain district of Canterbury.

PETROLOGICAL NOTES.

The remainder of this paper consists of notes on the petrology of the region. These tend to show that the rocks are in all probability not truly Archæan, but are metamorphosed igneous rocks, with perhaps occasional metamorphosed sedimentaries. This conclusion is based on the following evidence :—

(1.) The rocks never appear to exhibit that profound metamorphism which characterizes most Archæan rocks.

(2.) Frequently the only sign of metamorphism is the presence of strain and cataclastic effects : gradations in these can be traced from rocks practically without them to those which exhibit them to a marked degree.

(3.) The rocks do not show the effects of heat on their mineralogical character as they would if they were truly Archæan and had experienced subcrustal changes. They belong to the upper or middle zone of Grubenmann.

(4.) Rutile is a prominent constituent of the rocks, and this suggests that some may be altered sedimentaries. Mica-schists, however, are very seldom met with.

(5.) The marbles occurring at Milford and elsewhere seem to be the result of alterations in igneous rocks (see Marshall), and are not due to change in detrital or organic limestone.

It will be seen that the rocks are generally of somewhat acid character, and consist of true gneisses and diorite gneisses, with oligoclase as the dominant feldspar. Quartz and epidote are prominent constituents, titanite and rutile minor ones, the two latter being occasionally derived from ilmenite. The ferro-magnesian minerals are chiefly hornblende and biotite, although hypersthene and augite occur freely at times; garnets are very common.

Amphibolites are of frequent occurrence, and perhaps are basic segregations from the hornblende gneisses, which may represent metamorphosed diabases. In the northern part of the area peridotites and allied and associated rocks are strongly developed.

PRESERVATION INLET.

Specimens were collected at Kisbee Bay, on the south-east side of the inlet; some from boulders on the beach.

Diorite Gneiss (K 1).—This is a distinctly foliated rock, grey in colour. Under the microscope it appears composed of tolerably even-grained elements, consisting of much plagioclase (andesine), a little quartz, greenish-brown hornblende, biotite, grains of ilmenite, occasional titanite and epidote, frequent needles of apatite, and a few zircons.

Diorite (K 2).—A dark-grey rock formed chiefly of hornblende, showing cleavage-surfaces plainly. In section it shows much hornblende in large green crystals and plates exhibiting fibrous structure. The feldspar (oligoclase-andesine) is in smaller proportion; a small amount of quartz is present; biotite occurs in laths, epidote in grains and aggregates derived from hornblende. There appear to be intergrowths of hornblende with mica; ilmenite is common in grains.

Granite.—Granites of various degrees of coarseness are met with, the coarser types with pink feldspar crystals; some of the finer rock types are pinkish and reddish as a whole. The coarse-grained ones contain both orthoclase and plagioclase, both micas, interstitial quartz, and titanite in grains derived from ilmenite. In some of the specimens there is very little muscovite, and an occasional garnet and zircon; epidote occurs sparingly. The Preservation Inlet granites have been described by Hutton (10) as syenites.

CHALKY INLET.

The only rock from here is a gneissic granite from North Port. It is dark grey in colour, very indistinctly schistose, with biotite feldspar and quartz plainly visible. Under the microscope it shows occasional strain-effects. The feldspars are of both kinds, containing much sericitic material and at times micrographically intergrown with quartz; more biotite is present than in Preservation Inlet granites, and the flakes are frequently bent; muscovite is an important constituent; apatite needles, small garnets, and zircons are also present.

DUSKY SOUND.

Collections were made at Pigeon Island, at Duck Cove on Resolution Island, and at Pickersgill Harbour on the south side of the Sound, where Captain Cook established in 1768 a temporary astronomical station.

Gneiss (D 1).—From Pigeon Island. In the hand-specimen the rock is whitish, showing indistinct foliation; quartz, feldspar, and biotite, and some garnet, are plainly visible. Under the microscope it appears composed of much quartz in variable-sized grains, and feldspar (orthoclase) showing the effects of strain; plagioclase and microcline are both present; some of the feldspar exhibits schiller effects; there is much biotite, some epidote and hornblende, and sphene in idiomorphic crystals occasionally included in mica and hornblende; a little apatite and zircon are present; the structure is at times cataclastic.

Gneiss (D 2).—From Pigeon Island. In the hand-specimen the rock shows marked schistose structure. It is composed of microcline, plagioclase, quartz, muscovite, and biotite; granophyric growths are common; the structure is markedly cataclastic.

Garnet Pyroxene Gneiss (D 3).—From Duck Cove. This is the rock (G 24) described by Marshall (14). It shows abundant garnets, as well as a green F.M. mineral associated with a white feldspar. In section it is composed of plagioclase, a little orthoclase, a fair amount of quartz, and garnets in grains with borders of pale-green secondary monoclinic pyroxene derived from the garnet, which shows marked signs of corrosion. A good deal of hornblende also occurs, a small amount of biotite, and much strongly pleochroic secondary epidote; rutile in small grains is of frequent occurrence.

Gneiss (D 4).—From Duck Cove. A schistose rock showing epidote freely. It is composed of partially sericitised feldspar, partly plagioclase, a small amount of quartz, greenish hornblende, and strongly pleochroic secondary epidote (much of the epidote so frequently met with in the area appears to be primary). Ilmenite occurs in grains, with much secondary sphene in grains and aggregates derived from it, as well as apparently primary sphene in idiomorphic crystals; apatite needles are common.

Amphibolite (D 15).—From Duck Cove. A dark rock formed chiefly of hornblende in rude parallel arrangement. In section it is composed almost wholly of green-brown hornblende, much rutile in grains and idiomorphic needles, occasional grains of sericitised feldspar packed in between the hornblende; a small amount of yellowish epidote also occurs.

Gneiss (D 16).—From Duck Cove. A markedly schistose rock, showing the effects of pressure plainly in the hand-specimen. The structure is completely cataclastic, the rock being composed of grains of quartz, microcline, and feldspar showing strain-effects; brown mica occurs in well-marked parallel arrangement.

Gneiss (D 17).—From Duck Cove. This is the same as Marshall's G 13. It is composed of much quartz in irregular grains, plagioclase and microcline, biotite and muscovite in about equal proportions, the latter sometimes crowded with needles of sillimanite; the structure is cataclastic.

Gneiss (D 18).—From Duck Cove. A greenish-white rock completely crushed to a fine aggregate of feldspar and quartz, with a few larger partially sericitised crystals of feldspar; there are a few larger quartz grains still left, and numerous flakes of muscovite in parallel arrangement.

Mica-schist (D 5).—From Pickersgill Harbour. This is a dark compact rock, not showing schistose structure in the hand-specimen. In section it appears as a fine-grained rock composed of brown mica in small irregular flakes and small grains of quartz, with muscovite laths in rough parallel arrangement; small black grains of iron-ores in aggregates and strings are extremely common. This rock closely resembles a mica hornfels, and is probably due to the effect of a granite intrusion.

Gneiss (D 6).—From Pickersgill Harbour. The rock exhibits well-marked schistose structure. It is composed of much quartz; feldspar, both twinned and untwinned; occasional microcline; dark and light mica, sometimes intergrown; aggregates of epidote grains; ilmenite; apatite in short needles. Granophyric structure is common, and the whole rock shows the effect of pressure.

DAGGS SOUND.

The only type of rock found on this occasion in Daggs Sound was a gneiss (G 1) exhibiting marked schistose structure, white in colour, but speckled with greenish hornblendes. Under the microscope it proves to be a diorite gneiss. It contains the following minerals: Much oligoclase, frequently showing strain-effects, hornblende in corroded crystals, green in colour, and altered to aggregates of epidote and chlorite. Epidote also occurs along the cleavage-planes of the feldspar and as numerous grains and aggregates. Ilmenite occurs freely as grains, and at times forms irregular granular masses. Occasional mica and interstitial quartz also occur. The structure is moderately cataclastic.

THOMPSON SOUND.

Collections were made at Wood Head, at the head of Gaer Arm, and at Deas Cove.

Diorite Gneiss (G 2).—From the head of Gaer Arm. In the hand-specimen this is a yellowish-white rock with speckles of dark-green hornblende, indistinctly foliated. Under the microscope it exhibits an even-grained texture, with occasional strain-effects. The feldspar is an albite-oligoclase, often micrographically intergrown with quartz; quartz is present in quantity, sometimes intergrown with hornblende; hornblende, greenish-brown in colour, is a very prominent constituent; biotite occurs in broad plates, hypersthene in grains strongly pleochroic in pink and green, and a little augite.

Epidote Gneiss (G 3).—From head of Gaer Arm. This is a rock composed of feldspar frequently in foliæ, with dark foliæ of hornblende and mica, and very prominent yellowish-green epidote grains. In section, epidote in large grains and needles appears to be the most prominent constituent, greenish hornblende and brown mica, with much sphene, in grains and idiomorphic crystals. There is much feldspar (oligoclase) and some quartz, but some of the apparent quartz is clear colourless feldspar; apatite occurs in short needles.

Feldspar Quartz Rock (G 4).—From the head of Gaer Arm. This is a white rock, which appears in section to be composed of plates of oligoclase, large grains of quartz exhibiting undulose extinction, and small amounts of muscovite and epidote.

Mica-schist (G 5).—From Wood Head, at the junction of Doubtful and Thompson Sounds. In the hand-specimen this appears as a dark-grey schistose rock with lustrous mica surfaces, not very distinctly foliated. Under the microscope it shows well-marked parallel arrangement of the elements, which are almost wholly quartz, with brown and white mica; a little turbid feldspar occurs, and grains of ilmenite and hæmatite. This rock is in all probability an altered sediment.

Diorite Gneiss (G 5).—From Wood Head. A rock composed of feldspar with speckles of dark-coloured constituents, schistose in structure. The microscope shows the presence of feldspar frequently clear and colourless and resembling quartz, a small amount of quartz being undoubtedly present; the other constituents are greenish mica, much greenish hornblende, epidote in grains, ilmenite passing into leucoxene, and anhedral rutile in sufficiently large grains to show a uniaxial interference figure; apatite needles also occur.

Hornblende Schist (G 8).—From Deas Cove. A dark-coloured rock showing in section that four-fifths of the rock is yellowish-green hornblende slightly pleochroic; some feldspar occurs, and a little quartz in grains, but the amount is quite subordinate; grains of rutile are very common. This rock is evidently the same as Marshall's G 26.

Gneiss (G 10).—From Deas Cove. This is a white rock composed of quartz in rounded grains, much microcline, oligoclase, numerous shreds of muscovite, and very occasional garnets. Areas exhibiting granophyric intergrowths occur, strain-effects are common, and morter structure is well shown in places.

Another specimen (G 9) from the same locality is very similar, but contains biotite and a little muscovite and less microcline. This appears to be like Marshall's A 9.

GEORGE SOUND.

The specimens were collected at the head of the Sound, near the track to Lake Te Anau.

Gneiss (G 6).—A light-grey rock, not distinctly foliated. In section it is composed of clear feldspar (oligoclase), with some untwinned feldspar probably orthoclase; much quartz; much epidote in large grains: both muscovite and biotite occur, and sphene in grains. The structure is slightly cataclastic.

Gneiss (G 11).—A white rock with a few large flakes of biotite. The rock is almost all feldspar (oligoclase), some quartz, and muscovite in ragged flakes. The feldspar has schiller inclusions regularly arranged parallel to basal and brachypinacoids, and contains irregularly disposed areas of microcline.

Diorite Gneiss (G 18).—A dark-coloured, rather fine-grained, distinctly foliated rock. Under the microscope the rock appears even-grained, more than half composed of hornblende and biotite, with both, especially the mica, in rudely parallel arrangement. There are colourless grains of epidote, and sphene in numerous grains. The quartz and plagioclase are in about equal proportions.

Diorite Gneiss (G 7).—Similar to G 18, but more basic. This is a schistose rock with distinct foliæ of feldspar and dark minerals. The feldspar is oligoclase, accompanied by a little quartz. There is much hornblende and biotite, the former more important; occasional epidote; and numerous grains of sphene, both dark and pale coloured.

BLIGH SOUND.

These rocks were collected on the north side of the river entering the sound.

Hypersthene Diallage Gneiss (B 1).—A pinkish-grey rock, distinctly foliated. The feldspar is clear; there are grains of quartz, hypersthene with characteristic pleochroism and straight extinction, also diallage, and a little biotite and ilmenite. Dr. Marshall has pointed out to me the resemblance between this rock and a mica norite from the Darran Mountains, Milford Sound (14). Both rocks contain the same minerals, but on comparing slides his specimen appears more basic, and is without the gneissic structure so markedly exhibited by the rock from Bligh Sound. This occurrence may, however, be a gneissic variety of the mica norite.

Diorite Gneiss (B 2).—An indistinctly foliated rock. The feldspar is oligoclase in broad plates with faulted and bent lamellæ, at times crowded with inclusions of epidote needles and crystals, similar to the rock from the Bowen Falls mentioned by Marshall. There are corroded crystals of hornblende, sometimes with schiller-like inclusions parallel to the base, and filled with grains of quartz (*quartz de corrosion*); a small amount of other quartz also present, and numerous large individuals of epidote and flakes of biotite. There are grains of ilmenite surrounded by aggregates of sphene which are evidently formed from it.

Hypersthene Amphibolite (B 3).—This is a dark-green rock, which appears under the microscope to be composed principally of greenish-brown strongly pleochroic hornblende, with schiller-like inclusions; some of this may be altered augite. There is a considerable quantity of hypersthene, a little olivine and augite. A small amount of oligoclase occurs, and much rutile in grains. The rock was not found *in situ*, and it may be a basic variety of a diorite found in the locality, but it shows no foliation or parallel arrangement of the elements. The rock is related to a cortlandtite; but there is little olivine present, and this is not in pœcilitic grains as in a typical cortlandtite, but wedged in between the hornblende elements.

Diorite (B 4).—A rock formed of equal parts of feldspar and dark constituents, not distinctly foliated. In section it is composed of oligoclase, a little quartz, much epidote, a fair amount of greenish-brown hornblende, some biotite, and grains of sphene. It is an even-grained directionless rock, with little, if any, sign of pressure.

McKINNON PASS.

Two rocks from this locality, a wehrlite and a gneiss, have been recorded by Marshall. The present specimens, with one exception (the first enumerated), were collected on the western side of the pass.

Hornblende Schist (C 1).—From the Clinton Valley, near the Pompolona Huts. In the hand-specimen this is a dark-greenish rock, with cleavage-faces of hornblende plainly visible. Under the microscope more than half of the rock is of brownish-green and bluish-green hornblende, with numerous inclusions of rutile and ilmenite. The feldspar is oligoclase, and some quartz is present, as well as a few shreds of biotite and muscovite.

Gneiss (M 1).—This is a distinctly foliated whitish rock, with quartz and muscovite clearly visible to the eye. In section it is composed of much quartz, plagioclase, and microcline, biotite and muscovite, epidote in grains, and sphene. The elements have a rudely parallel arrangement, strain-effects occur, and the structure is partly cataclastic.

Diorite Gneiss (M 2, and M 4–8, 11–15).—These specimens, all from the western side of the top of the pass, include a number of distinctly and indistinctly foliated rocks, showing hornblende freely, and occasional garnets. In section they are composed of brownish-green and blue-green hornblende; biotite in broad plates quite subordinate to the hornblende; occasional muscovite; and much epidote, both colourless and yellow, in crystals, grains, and granular aggregates. The feldspar is oligoclase, usually clear, with quartz in varying amount, but sometimes an important constituent. Rutile is plentiful as brown grains and needles, titanite is also present at times, and an occasional garnet. Cataclastic structure is frequent.

Hornblende Epidote Schist (M 3).—A dark-grey indistinctly foliated rock, composed of greenish-blue and greenish-brown hornblende, biotite subordinate in amount to the hornblende, muscovite, a little feldspar, much quartz, and a large amount of epidote; rutile grains are common. This rock is apparently a variety of the diorite gneiss in which feldspar is practically absent.

Amphibolite (M 9).—A dark rock composed chiefly of hornblende. In section it is composed of the usual hornblende, greenish-brown and -blue in colour, forming seven-eighths of the rock; occasional muscovite; much epidote; and brown grains and needles of rutile.

Gabbro (M 10).—A dark-green rock, distinctly schistose, with greasy feel. In section it appears markedly cataclastic, and composed of greenish hornblende much crushed and fibrous, some apparently derived from the pyroxene. There occurs also greenish faintly pleochroic diallage; enstatite; with serpentine and talc, which may have been derived from the olivine, but undoubted evidence of this is lacking. Granular sphene is common, and a considerable amount of feldspar, untwinned, and probably of secondary origin, being quite clear, but crowded with needle-like crystals of pale-green colour and with oblique extinction, in all probability actinolite. A part of this clear mineral may be secondary quartz. Unaltered feldspar occurs in small amount, the grains being completely crushed. The rock appears to be a crushed gabbro or wehrlite.

ANITA BAY (MILFORD SOUND).

Captain Hutton (11) has described hornblende diorites and enstatite gabbros from Milford Sound, specially from Harrison's Cove, and Dr.

Marshall (14) notes, with descriptions, gneisses and hornblende schists from Milford, but he has devoted special attention to the basic rocks at Anita Bay, on the southern side of the entrance to the Sound. He has recorded from there hornblende schists and gneisses, bowenite, dunite, and harzburgite, the last-named passing into marble. Finlayson (3) has also referred to the bowenite, and the matrix in which it occurs. This locality, owing to its remoteness and the thick covering of bush, is very imperfectly known, and the present author was able to collect a number of other rocks mostly from boulders which can only have come from the adjacent hillsides; but the marble passing into harzburgite was found in position as veins in a dark indistinctly foliated rock at the western point of the bay. The following types were met with, and will serve to emphasize the remarkable variety of rocks occurring there, and the difficulty of fully establishing their true relationships.

Hornblende Garnet Gneiss (An. 1).—This is a markedly schistose rock, with many garnets visible to the eye. Under the microscope it is composed of large irregular reddish garnets, with quartz (probably *quartz de corrosion*) and rutile inclusions. There is a considerable amount of greenish hornblende, and some flakes of brown mica. Much quartz occurs in rounded grains with undulose extinction, and feldspar (andesine) frequently exhibiting wavy and broken twin lamellæ. Zoisite occurs, very occasional epidote and muscovite. and much brown rutile in grains included in the garnets and mica.

Hornblende Garnet Gneiss (An. 9).—A dark, even, fine-grained rock, showing in section much garnet in grains, and the minerals of the preceding rock, but the texture is much finer-grained and shows the effects of pressure. The biotite flakes are bent round the larger elements in pseudofluxion structure.

Garnet Gneiss (An. 10).—This is a pink-grey distinctly schistose rock. It contains much garnet in grains, with inclusions of quartz and feldspar sometimes closely resembling graphic intergrowths; the garnet is cracked, and has both muscovite and biotite freely developed in the cracks. Flakes of both these micas occur, and much quartz and feldspar twinned and untwinned; apatite needles are occasionally to be seen. Pressure granulation is very prominent.

Diorite Gneiss (An. 14).—A rock showing much dark-green hornblende and feldspar, distinctly foliated. It contains much greenish and bluish-green hornblende, passing into chlorite and epidote; plagioclase, and some quartz. Another variety (An. 15) of this gneiss contains long needles of epidote, and flakes of muscovite included in the feldspar.

Hornblende Garnet Gneiss (An. 11).—This is a distinctly foliated rock, composed of much hornblende frequently intergrown with garnet, garnet in grains, some faintly pleochroic epidote, columnar aggregates of zoisite, a little brown mica and muscovite, quartz and much plagioclase, brown grains of rutile.

Dunite (An. 5).—This is similar to Marshall's rock, but it contains occasional enstatite as well as diopside. The structure is markedly cataclastic.

Harzburgite (An. 3, 4, 6, 7).—Some of my specimens are similar to those described by Marshall (13), but others contain much augite with occasional diallage structure. The olivine is partially serpentinised, and apparently passes into talc, as flakes and aggregates of that mineral occur frequently, and specially as inclusions in the carbonate present in the rock.

This is well shown in the specimens from veins on the west side of the bay, where the rock approaches a sagvandite (Rosenbusch's "Elemente der Gesteinslehre," p. 549). Large quantities of carbonate are found in the rocks containing much diallage, as well as in the normal harzburgite, showing that the enstatite in other ultrabasic rocks passes into carbonate; unless, indeed, the process is a reverse one, and this marble is passing into a magnesian silicate rock owing to the effect of an intrusive mass of dunite. However, in some cases here the alteration enstatite to talc certainly occurs, as crystals occasionally show a change in that direction.

Besides the above, large boulders of rocks of somewhat abnormal type were found. They cannot have come from a distance, and they show connections with the rocks found in position. They are distinctly foliated, and contain a large amount of garnet. The first is a greenish-grey rock with a tinge of pink, close-grained, showing faint schistose structure: it is composed principally of reddish garnet, with augite, olivine, titanite, and chromite, some quartz of secondary origin, and much carbonate (calcite or dolomite); the garnet grains are in strings and aggregates, often in rudely parallel arrangement, and show marked signs of crushing; the whole structure is cataclastic. The second specimen is a green rock, with cleavage-surfaces of green augite strongly showing: it is composed of greenish augite occasionally showing diallage structure, grains of olivine which are clear and only occasionally passing into serpentine, occasional enstatite, and much crushed garnet of slightly reddish tint in grains distributed irregularly but sometimes collected in masses; the structure is markedly cataclastic. The first of these rocks is a eulysite or garnet peridotite, in connection with which it may be observed that Rosenbusch, in his work referred to previously, has noted the association of carbonates with rocks of this type. The second rock contains much less garnet, and is more closely related to the dunite. As it contains a considerable amount of monoclinic pyroxene it should perhaps be called a garnet-wehrlite. Both of these rocks seem to be modifications of the ultrabasic intrusions which have penetrated the gneisses of this area, and belong to that great series of intrusions which occur up the western side of the Southern Alps to Nelson and reappear in New Caledonia. The date of the New Zealand intrusions was first of all considered as Devonian, but the consensus of opinion at the present would make them much younger, probably Upper Jurassic or Lower Cretaceous; however, according to the reports of Messrs. Pelatan and Piroutet, the serpentines and allied rocks of that island, which is so closely connected geologically with New Zealand, are certainly post-Cretaceous, and there is no reason why the New Zealand rocks of like facies should not be of the same date. An inference drawn from two widely separated localities is certainly somewhat dangerous; but the almost entire absence of fragments of ultra-basic rocks in detrital deposits in this country is certainly suggestive, although explanations of their absence can be readily put forward, and of course they may be discovered after a further examination of the deposits. The date of the intrusion of the New Zealand peridotites may be as recent as Tertiary times and possibly late Tertiary times.

In concluding, the author wishes to acknowledge the imperfect and unsatisfactory character of these petrological notes; they will serve, however, to mark the complex character of the area, and to emphasize Captain Hutton's conclusion that the rocks are not truly Archæan, but metamorphosed igneous, with perhaps metamorphosed sedimentary rocks included among them

BIBLIOGRAPHY.

1. Andrews, E. C. "Some Interesting Facts concerning the Glaciation of South-western New Zealand." Report Aust. Assn. Adv. Sci., vol. x, 1904.
2. Andrews, E. C. "New Zealand Sound Basins." Journal of Geology, vol. xiv, 1906.
3. Finlayson, A. M. "On the Nephrite and Magnesian Rocks of New Zealand." Quart. Jour. Geol. Soc., vol. lxv, 1909.
4. Hector, Sir James. "Geological Expedition to the West Coast Sounds of Otago." *Otago Provincial Gazette,* 1863.
5. Hector, Sir James. "On the Geology of the Province of Otago." Geol. Mag., vol. i, 1864.
6. Hector, Sir James. "On the Geology of Otago, New Zealand." Quart. Jour. Geol. Soc., vol. xxi, 1865.
7. Hector, Sir James. "Origin of Rock Basins in New Zealand." Geol. Mag., vol. ii, 1865.
8. Hutton and Ulrich. "Geology of Otago." 1875.
9. Hutton, F. W. "On a Hornblende Biotite Rock from Dusky Sound." Quart. Jour. Geol. Soc., vol. xliv, 1888.
10. Hutton, F. W. "The Eruptive Rocks of New Zealand." Jour. Roy. Soc. N.S.W., vol. xxiii, 1889.
11. Hutton, F. W. "On the Foliated Rocks of Otago." Trans. N.Z. Inst., vol. xxiv, 1892.
12. Hutton, F. W. "Corrections of the Names of some New Zealand Rocks." Trans. N.Z. Inst., vol. xxxi, 1899.
13. Marshall, P. "Magnesian Rocks at Milford Sound." Trans. N.Z. Inst., vol. xxxvii, 1905.
14. Marshall, P. "Geological Notes on the South-west of Otago." Trans. N.Z. Inst., vol. xxxix, 1907.

ART. XXXI.—*An Apparent Relation between some of the Physical Properties of Solids.*

By S. PAGE, B.Sc.

[Read before the Philosophical Institute of Canterbury, 1st December, 1909.]

THE usual conception of the mechanical structure of solids is that the finite particles or molecules composing them are held together by forces of mutual attraction called "cohesion." In rigid solids these forces are such that very little change can occur in the relative position of the particles. The greater the force of cohesion, the greater must be the counter-force necessary to separate the particles, the greater the resistance to breaking-down of the solid.

This breaking-down of the solid can take place in several ways, of which the following are the chief: (1) Mechanical rupture, crushing, &c.; (2) solution in a liquid solvent; (3) volatilisation, with or without fusion as a step in the process.

The energy required to break down and completely overcome the cohesion of a given mass of solid should be the same in amount whether that breaking-down be accomplished by crushing, by solution, or by fusion and volatilisation.

Measurements are made of these three kinds of change in solids in various ways, the more important of which are as follows :—

Case 1 : *Mechanical Rupture.*—This is measured by—(*a*) tensile strength ; (*b*) crushing strength ; (*c*) hardness, &c.

In isotropic solids the force to be overcome is the same for all of these methods, and the results expressed in suitable terms should be comparable. But most solids are not isotropic ; mica, selenite, and asbestos may be cited as extreme cases where the strength in different directions is totally different. In all such cases different methods of measurement may give quite different values for the mechanical strength. For present purposes the determination of hardness, although by no means precise or exact, is perhaps the most useful. It is very easy to measure roughly, so that where the hardness differs much in different directions the maximum value is easily found.

Case 2 : *Solution in a Solvent.*—This method of breaking down a solid is measured usually in terms of the weight of solid which dissolves in a given weight of solvent at a definite temperature. In a given solvent at a given temperature the solubility depends upon two principal factors—first, the attractive force or adhesion between solid and solvent ; and, second, the cohesion of the solid. Assuming the first to be nearly constant, the solubility should increase as the cohesion and the mechanical strength become less.

Case 3 : *Fusion and Volatilisation.*—This, the third method given for separating molecules, is a question of two opposing forces—molecular cohesion *versus* molecular velocity. When the average kinetic energy of the moving molecules is greater than the energy of cohesion, the molecules escape from each other and volatilise. With any given solid the energy of the moving molecule increases with the temperature proportionately, while the cohesion remains the same. Hence the greater the cohesion and mechanical strength, the higher the temperature required for volatilisation, or fusion and volatilisation.

In the absence of suitable quantitative measurements, which, as already seen, are particularly difficult to get in the case of mechanical strengths, no exact correspondence can at present be shown between strength, solubility, and volatility or fusibility in solids, but evidence enough is available to show distinctly that some such correspondence exists.

In a chemical laboratory hundreds of artificially prepared pure solids are met with. Owing to the limitations of manufacturing processes, these are almost entirely confined to compounds readily soluble, or fusible, or volatile, and in every case the crystals are mechanically soft and weak—in fact, softness and weakness are the most striking characteristics of artificially prepared crystals. Quite recently the high temperatures of the electric arc have come into commercial use, and one of the most notable results is the formation of new and difficultly fusible crystals, such as carborundum, which is little short of a diamond in hardness.

A few more definite examples may be given. If we arrange six of the more common salts of calcium in order of increasing hardness, thus—chloride, carbonate, sulphate, phosphate, fluoride, silicate—it will be found that this is also the order of increasing insolubility.

In the closely related compounds, sugar, starch, and cellulose, the insolubility and strength increase together very clearly, sugar being freely soluble and weak, starch semi-soluble and comparatively strong, cellulose insoluble and very strong.

In the numerous commercial glasses, all those easily fusible are soft; hardness and infusibility increase together. Very much the same is true of the resins.

All the solid hydrocarbons are very easily melted, and all are very soft and weak.

Ordinary phosphorus is readily fusible, soluble, and very soft, while the change which converts it into red phosphorus makes it difficultly fusible, and at the same time insoluble and relatively hard.

There are a few prominent cases which appear at first sight to be exceptions to the general rule. All the forms of carbon are highly infusible and insoluble, but some are quite soft. The explanation appears to be that the soft forms are not compact; the particles are not close enough for cohesion to have full play. Any process which makes the carbon more dense and compact increases very largely its strength and hardness. This is very well seen in the manufacture of the glow-lamp filament. Ordinary charcoal does not seem a promising material to make into a strong, hard, elastic wire; yet by simply increasing its compactness, bringing a greater proportion of the molecular particles within reach of each other, the required strength and elasticity result. Similarly, retort carbon is hard and strong. The softness of charcoal is due to its spongy, open character. Alumina and its important compound clay are very insoluble and difficultly fusible, and yet both are soft and unctuous to the touch. That this also is due to the loose, open structure, to the molecules being too far away to hold each other firmly, is pretty clear. Clay, when strongly heated, shrinks very much, the particles come within closer reach of each other, and the mass becomes both hard and strong. The change is well seen in the manufacture of bricks and pottery. If the heating be very prolonged, the clay may actually crystallize, as in the mineral andalusite, which is harder even than quartz. Alumina can be melted in the electric arc, and then forms a compact solid, with the strength and hardness of the ruby.

Quartz is much more infusible than any glass, and after fusion is proportionately stronger—so strong that thin crucibles of quartz can be plunged into cold water while red-hot without injury.

In practically every case, then, with resistance to solution, or fusion, or volatilisation comes resistance to mechanical rupture. Hence strength and hardness may be to a great extent foretold in compact solids if the solubility or fusibility be known, and *vice versâ.*

The matter has been brought before the Institute in order to make a little more clear and definite a relation long felt more or less vaguely, and utilised more or less consciously by many practical men.

ART. XXXII.—*A Possible Relation between Atmospheric Carbon-dioxide and Leaf-development.*

By S. PAGE, B.Sc.

[*Read before the Philosophical Institute of Canterbury, 4th August,* 1909.]

THE existence of all green plants is dependent upon atmospheric carbon-dioxide, and this is relatively so small in amount that the annual growth of plants the world over absorbs each year a very appreciable proportion of the whole supply. Liebig calculated that in Central Europe one acre of vegetation removes three-fifths of a ton of carbon per year; and Arrhenius,* using this estimate, finds the annual carbon-production of plants the world over to be 13,000 million tons—not less than one-fiftieth of the whole CO_2 of the atmosphere. Although the greater part of this, by decay, goes back into the air each year, Arrhenius estimates that the carbon annually obtained from the air and stored up as peat would use up all the atmospheric CO_2 in ten thousand years.

Existing peat and fossil carbon generally, corresponds approximately in amount to the oxygen of the air—that is, would require the whole of the atmospheric oxygen to burn it up completely. Hence it was suggested by Keohne, of Brussels, in 1856, that all the oxygen of the air—1,216 billion tons—may have been produced from CO_2 by plants.

It is clear, then, that the relation between plants and the world's supply of CO_2 is a very intimate one, and that any considerable fluctuations in the aerial proportion of this essential gas is likely to be of supreme importance to plant life. That fluctuations have occurred—that at one time in the earth's history the amount of CO_2 in the atmosphere was very different from and very much greater than at present—there is a good deal of evidence to show. There can be no doubt that at one time the crust of the earth was at a high temperature, above its melting-point, and far above the ignition-point of carbon in air. Hence any free carbon whatever which reached the surface of the fluid earth during this period—a very long period—must have been burnt into CO_2. Not only so, but the free carbon below the surface, protected from air, could scarcely escape oxidation by the water and metallic oxides of the molten mass.

Practically all metallic oxides are now known to be reducible by carbon at very high temperatures, and many igneous rocks, old and new, undoubtedly contained considerable water while in fluid or semi-fluid condition.

It has been suggested by Mendeléef and others that at this stage the carbon escaped oxidation by forming metallic carbides similar to the iron-carbides of cast iron and the now well-known calcium-carbide used for generating acetylene. But carbides are readily oxidized into CO_2 by water, air, or metallic oxides. Examples of such action are found in the Bessemer converter and in the production of steel from cast iron by burning out the contained carbon with oxides of iron. The traces of CO_2 now found occasionally in rocks in the liquid form may possibly have their origin in some such deep-seated oxidation of carbon or carbides.

The weight of evidence, then, appears against the supposition that the bulk of the earth's carbon was retained in the crust during the hot period, and tends to show that it was burnt into CO_2 and found its way into the atmosphere.

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* "Worlds in the Making."

Let us compare, then, the quantities of carbon at present existing in the earth's crust and in the air respectively, in order to see how far the aerial supply would be increased if all known carbon existed as CO_2:—

Percentage of CO_2 in air = by volume ·04.
Percentage of carbon in air = ·04 × 3/11 = ·011 (nearly).
Atmospheric carbon in pounds per square inch of earth's surface $\frac{\cdot011}{100} \times 15 = \cdot0016$.

Percentage of C in earth's crust .. .. = ·21 (F. W. Clark).
Density of crust .. .. = say, 3.
Terrestrial carbon in pounds per cubic inch of crust $\frac{62\cdot5 \times 3}{1728} \times \frac{\cdot21}{100} = \cdot00022$.

$$\frac{\text{Atmospheric carbon per square inch of crust}}{\text{Terrestrial carbon per cubic inch of crust}} = \frac{\cdot0016}{\cdot00022} = 8 \text{ (approximate)}.$$

Hence, a column of the earth's crust 8 in. deep contains as much carbon as a similar column of air of the full depth.

Assuming the earth's crust to be fifty miles deep, if 1 per cent. of its carbon was burnt and thrown into the air, the atmospheric CO_2 would be increased more than three thousand five hundred times.

The problem as to the amount of CO_2 formerly in the air may be considered also from another point of view.

Plants are not and never have been the only absorbers of CO_2. The weathering of rocks is ceaseless. Many igneous rocks consist largely of silicates of potassium, sodium, calcium, magnesium, and iron. CO_2 dissolved in rain-water converts these into carbonates. Hence the probability of all the CO_2 found as carbonates in the sedimentary rocks being obtained from the air.

Hogbom estimates that the earth's limestones and dolomites contain twenty-five thousand times as much CO_2 as the air.

Chamberlin (American geologist), omitting the pre-Cambrian (pre-plant) limestones, estimates that those formed since life appeared contain twenty to thirty thousand times as much CO_2 as the air.

It is absolutely clear, therefore, that the air was once enormously richer in CO_2 than now. Was this so when plants first appeared? Carbon separated from the air and now existing as fossil plants, coal, peat, &c., contains hundreds of times as much carbon as is now in the air; also, the limestones of fossiliferous periods contain twenty to thirty thousand times as much CO_2 as the air.

Unless, therefore, there has been a regular supply of CO_2 from volcanic vents or otherwise to balance this enormous removal of carbon, the atmosphere at the period when plant-life began must have been excessively rich in CO_2. Also, during the plant period the atmospheric CO_2 has been reduced apparently in a steady continuous progressive manner from a very large to its present very small proportion.

One need not be a biologist or botanist in these days of popular scientific literature and popular scientific lectures to be thoroughly familiar with the fact that environment has a great deal to do with the form, character, and habits of plants. Relatively small differences in temperature, in dryness of air or of soil, in wind, in altitude, in presence of insects or herbivorous animals, &c., produce in time great changes, and are largely responsible for the diverse plant forms now existing. And in the light of the present knowledge as to the effect of environmental changes, it is impossible to conceive that a change—huge, continuous, progressive—in a most vital condition, extending for thousands or millions of years, could be without a corresponding change in the plant forms dependent upon it.

The collection of the carbon essential to its existence is confined to the surface of a plant. The surface is the part most directly concerned. Hence, if any change occurs to balance this continuous impoverishment of the air, it should be in the direction of a modification of the surface.

Two distinct kinds of modification appear possible—(1) An increase in the effectiveness of the original surface; (2) an increase in the area of this surface.

For our own present purpose the first may be neglected, as it seems hardly possible to discover much about it.

As to the second, palæontological records show that the earliest plants, *other than ferns*, were practically leafless, and little branched. The ratio of surface to mass was comparatively small.

The lepidodendrons and calamites of the Devonian period were massive plants showing quite a small surface. Later plants showed more branching, more surface area; but it was not until late in the Carboniferous era, by which time immense amounts of CO_2 had been used up, that leaves were common.

An examination of plant-remains shows that since Carboniferous times a fairly continuous increase in the ratio of surface to mass in the dominant plants has taken place, until now the average flowering-plant shows an abundance of leaf, a ratio of surface to mass that has not been exceeded at any previous period.

It seems a fair inference, then, that the evolution of plant surface—in other words, the evolution of the leaf—has been primarily due to the necessity for more efficient CO_2 collection, and has been one of the results of the progressive diminution of atmospheric CO_2.

Arrhenius* points out that the actual amount of CO_2 in the air is so small that in 1904 the coal burnt produced CO_2 equal to one-seventieth of that of the air. The atmospheric CO_2 is consequently again increasing or likely to increase.

One objection to the suggestion that decrease of CO_2 has developed leaf surface is that ferns were amongst the earliest plants, and these exposed a comparatively large surface from the beginning. This was probably due to an entirely different cause.

Consider the factors in the development of plant surface. They appear to be of two kinds, respectively in favour of and against such development: In favour—(1) Need of CO_2; (2) need of sunlight. Against—(1) Drought; (2) wind (mechanical effect); (3) excessive sunlight.

The early forests appear to have been dense, and then, as now, ferns appear to have been forest-floor plants, living in partial shade. Forest-floor plants would be likely to have CO_2 in plenty, but little light. Light, however, is absolutely essential, and a plant growing in the shade can increase its light-collecting power only by spreading itself out as much as possible.

While there are many drawbacks to a great extension of surface in an exposed plant, on the forest-floor there is no wind to damage, no drought to shrivel, no sun to scorch.

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* "Worlds in the Making."

The problem arose much sooner, was much easier than in the case of exposed plants, and apparently was solved much earlier. I believe that at the present time these advantages still show, ferns are able to extend themselves recklessly—there are probably few exposed plants which rival the ferns in ratio of surface to mass.

The New Zealand kidney-fern possesses an extraordinary extension of surface in proportion to its mass; a young and vigorous New Zealand cabbage-tree also shows very considerable surface: but if cut and exposed to a drying wind the fern shrivels in a few minutes, the cabbage-tree scarcely in a week. The fern in gaining large surface has become excessively open to damage by light, by wind, and by drought; the cabbage-tree in gaining a great extension of surface has retained its power of resisting all three.

It seems, therefore, reasonable enough to assume that even if the necessity for increased surface arose at the same time in ferns and exposed flowering-plants, the latter, faced by such difficulties, would take much greater time to develop it safely.

ART. XXXIII.—*Some New Zealand and Tasmanian* Arachnidæ.

By H. R. HOGG, M.A., F.Z.S.

Communicated by Dr. C. Chilton.

[Read before the Philosophical Institute of Canterbury, 3rd September, 1909.]

FOR the phalangids and spiders now described, with one exception, I have to thank Professor Benham, of Dunedin, and Dr. Chilton, of Christchurch.

Coming from Tasmania, Stewart Island, and New Zealand, they are representative of the southern fringe of the families to which they belong, and I welcome this opportunity of placing them on record.

The extension of the genus *Pantopsalis* to Tasmania and of *Macropsalis* to Stewart Island does away with the older supposition that the former was peculiar to the New Zealand region and the latter to the Australian.

Order ARANEÆ.

Fam. DICTYNIDÆ.

Genus AMAUROBIUS, Sund.

Amaurobius charybdis, nov. sp.

The cephalothorax is red-brown in front, orange-brown on the thoracic part, and darker orange on the cephalic part, with a narrow median stripe and side stripes quite dark brown.

The mandibles are black-brown, the fangs black at the base, red towards the point. The lip and maxillæ dark red-brown. The sternum dark yellow-brown, with long upstanding brown hair.

Coxæ and legs bright yellow-brown, with bands of light grey, three on the femur, tibia, and metatarsus, and one on the patella. Palpi yellow, with grey hairs.

The abdomen is dark grey, mottled with small bunches of white or yellow hairs. Two rather broad longitudinal yellow stripes divided by a median grey stripe extend one-third the length from the front. In the centre behind these is a white pattern shaped like a St. Andrew's cross. On the under-side are four longitudinal pale-yellow stripes. The spinnerets are dark brown, the cribellum nearly white.

The *cephalothorax*, convex on the cephalic part, is furnished with some strong curved bristles over the anterior area; otherwise it is rather bare. The sides of the thoracic part are well rounded.

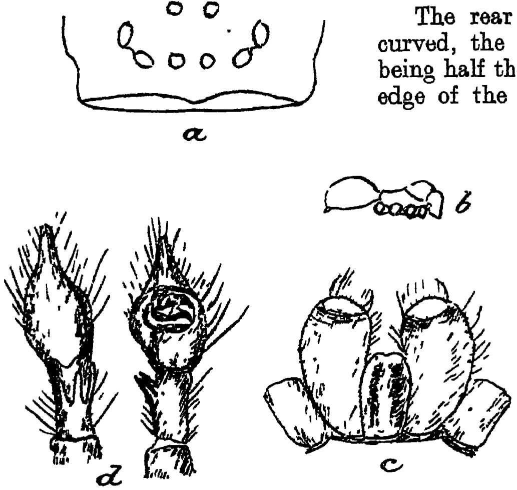

FIG. 1.—AMAUROBIUS CHARYBDIS.

a. Eyes. *b.* Profile, natural size. *c.* Lip and maxillæ. *d.* Male palp, front and back.

The rear row of eyes is strongly procurved, the lower edge of the median being half their diameter above the upper edge of the laterals The median eyes are 1½ times their diameter apart, and 2½ times of the same distant from the laterals, which are oval, their long diameter perpendicular. They are on a common tubercle with the front laterals, which are of the same size and shape but lying horizontally, and from these they are parted at the corners by a third of their length. The front row is straight. The outer edge of its side eyes lies just within the inner edge of the rear laterals. They are their long diameter distant from the median, which are as large as the rear median, and stand their diameter apart from one another, and more than twice that distance from the rear median eyes. The clypeus is twice their diameter.

The *mandibles* are long and powerful, kneed at the base, and furnished with long upstanding bristles. The fangs are long and well curved. There are three rather small teeth on the inner margin of the falx-sheath, and one large between two small on the outer.

The *maxillæ* are upright, straight on the inner edge and moderately rounded on the outer. The *lip* is one-third longer than broad, narrowed anteriorly, truncate with a slight hollow in front.

The *sternum* is shield-shaped, twice the breadth of the lip, and is raised up from the margin; it is covered with long upstanding hairs; it narrows to a point at the rear, and slightly projects between the two rear coxæ, which are not quite contiguous. These are also separated from the coxæ of the third pair.

The *legs* are moderately fine, tapering to their anterior ends. The front pair are remarkably long, being nearly 4½ times the length of the cephalothorax. There is no calamistrum on the male. The superior claws are strong and are well curved at the anterior end, with about nine teeth on the basal half.

The *palpi* are fine, and furnished with three apophyses on the back of the tibial joint.

The *abdomen* is oval, straight in front, rounded at the sides, and moderately high. It is covered with downlying thick bristly hair, interspersed with long upstanding bristles. The cribellum is divided, and stands up rather high above the level of the abdomen. The spinnerets are normal.

The measurements in millimetres are as follows :—

	Length.	Breadth.
Cephalothorax	6	4 (3 in front).
Abdomen	6	3½
Mandibles	3	

Legs.—	Coxæ.	Tr. and Fem.	Pat. and Tib.	Met. and Tars.		
1	2	6½	9	9	=	26½
2	2	6	7	7	=	22
3	2	5½	6	6	=	19½
4	2	6	6½	6½	=	21
Palpi	1	3	2	1½	=	7½

One male, from Stewart Island.

Fam. THOMISIDÆ.

Subfam. STEPHANOPSINÆ.

Group STEPHANOPSEAE.

Genus STEPHANOPIS, Cambr.

Stephanopis, Rev. O. P. Cambridge, Ann. & Mag. Nat. Hist., 1869, p. 60; L. Koch, Arach. Aust., 1874, p. 495; E. Simon, Hist. Nat. des Ar., vol. i, p. 1054.

Stephanopis benhami, nov. sp.

The cephalothorax is dull yellow with a darker triangular longitudinal median stripe reaching from the rear row of eyes to the top of the rear slope. The palpi, legs, lip and maxillæ, sternum, and both sides of the abdomen are about the same colour as the cephalothorax, the mandibles somewhat darker. On the upper side of the abdomen are three pairs of muscle spots.

The cephalothorax is triangular, widening from less than a millimetre in front to 2½ millimetres at the posterior end, the edge of which is straight. The skin is somewhat tuberculous, and thickly covered with downlying flat club-shaped bristles. The front part of the cephalothorax, on which lies the anterior row of eyes, is perpendicular to the remainder of the cephalic part, on the top of which is the rear row of eyes. The latter is slightly recurved, equal and equidistant, rather more than their diameter apart. The front row of eyes is strongly recurved, the laterals twice the diameter of the rear eyes, reaching up to the margin of the upper surface. The small median, one-third of the diameter of the latter, are their own diameter apart, and lie a little below the line joining the lower edge of the laterals. They are twice their diameter from the margin of the clypeus.

The *mandibles* are rather broad and straight. The lip is as broad as long, truncate in front, and reaches barely half-way up the maxillæ, which are straight at the anterior end, and nearly touch one another over the lip. The sternum is a broad oval, and the rear coxæ touch one another. The palpi are short and thick, thickly covered with bristly hair, and the patellar joint is as long as the tibial.

The femora of the front two pairs of legs are much thicker and broader than the rest. They are carried thrown back from the coxæ, the other joints pointing forwards, and are covered with short spatulate bristles on the upper side. On the under-side of the metatarsi of each are three pairs of stout spines, and on the under-side of the tibia four stout incurved pairs. These spines are much stouter on the front pair than on the second. There are also claw-tufts on the tarsi of the front two pairs. The rear two pairs are slighter and unarmed, with fine bristles under the tarsi.

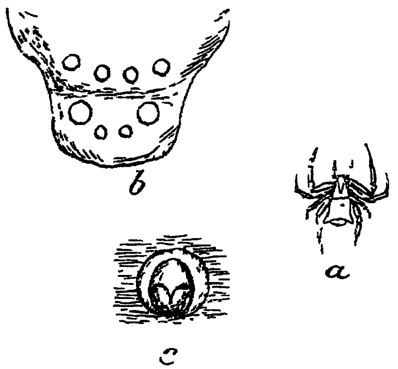

Fig. 2.—Stephanopis Benhami.

a. Natural size *b*. Eyes *c* Epigyne.

The *abdomen* is truncate in front, widening out to its greatest breadth at its posterior end, where it is slightly hollowed, and carries two angular tubercles at the corners. From thence in an inverted cone it sinks perpendicularly to the spinnerets. The epigyne is hollowed, with a horseshoe-shaped rim. The under-side of the abdomen is thickly covered with short spatulate bristles.

This species, in coloration, pattern of eyes, and shape of cephalothorax and abdomen, is very like L. Koch's *S. longipes*, from Rockhampton, Queensland. Besides being smaller, its front two pairs of legs are shorter in proportion, and the two rear pairs longer.

The measurements in millimetres are as follows :—

	Length.	Breadth.
Cephalothorax	3	2½ (1 in front).
Abdomen	3½	3
Mandibles	1	

Legs,—	Coxæ.	Tr. and Fem.	Pat. and Tib.	Met. and Tars.		
1	1	3½	3½	3	=	11
2	1	3	2½	2½	=	9
3	1	2	1½	1¼	=	5¾
4	1	3	2½	2	=	8½
Palpi	½	1	1	¾	=	3¼

One female, from Stewart Island.

I have named this species after the collector, Professor W. B. Benham.

M. Simon calls the genus *Stephanopsis*, possibly misled by the error in the Index of the Zoological Record, 1880-1900; but *Stephanopis* is the name originally given to the genus by the Rev. O. P. Cambridge, and it must be so spelt: *Stephanops*, moreover, is the name of an older genus of *Rotifera*.

The area of distribution of the genus covers pretty well the whole of the subtropical regions south of the Line, with the exception of Africa, although it reaches as far as Madagascar. This specimen is from the farthest-south point hitherto recorded.

Order OPILIONES, Sundevall.

Suborder PALPATORES, Thorell.

Fam. PHALANGIOIDÆ, Thorell.

Genus MACROPSALIS, W. Sorensen.

Macropsalis, W. Sorensen, Die Arachniden Aust., ii Halfte, p. 54, 1886, Opiliones ; R. I. Pocock, Proc. Zool. Soc. Lond., 1902, vol. ii, p. 398, New Harvest Spiders ; Dr. J. C. C. Loman, Zoologischer Jahrbucher, Band xvi, 1902, p. 163 *et seq.*, Neue Ausereurop. Opilione.

Macropsalis chiltoni, nov. sp.

This specimen from Stewart Island is the first of the genus which has been recorded from New Zealand, the species hitherto described having come from the mainland of Australia, while the New Zealand forms were believed to have all fallen into the allied genus *Pantopsalis*, E. Sim.

Carapace dark red-brown, with two parallel longitudinal orange stripes reaching from the sides of the eye-tubercle to the rear slope. Legs and femoral joint of palpi brown with yellow bands, remainder of palpi pale yellow. Abdomen grey in front, with two parallel black-brown stripes reaching from the anterior end half-way down the abdomen, the remainder black-brown.

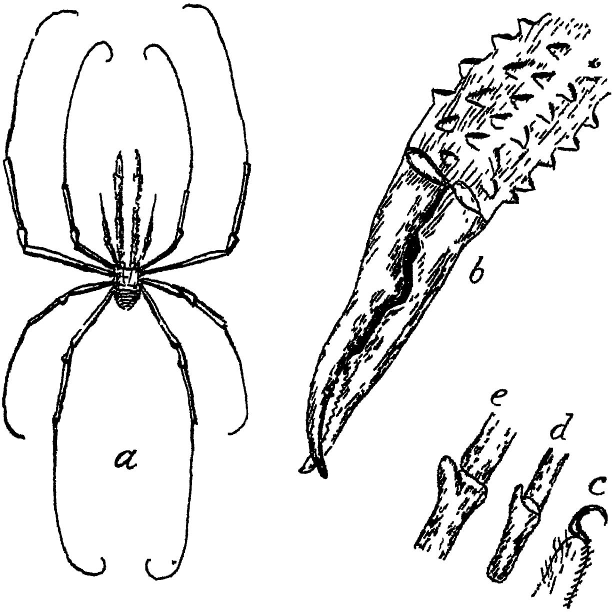

FIG. 3.—MACROPSALIS CHILTONI.

a. Natural size. *b.* Mandibular finger, enlarged. *c.* Palpal claw. *d.* End of tibial joint of palp, from inside. *e.* Same, from outside.

Of the mandibles the basal segment is yellow-brown, darkening anteriorly on the upper side. The second segment is dark red-brown above and yellow underneath.

With the exception of a few small spines on the eye-tubercle and in front of same, the whole carapace is quite smooth.

The mandibles are thickly covered with spicules and tubercles. They are thin, but widening out slightly at the anterior end of each joint. The fingers are long and thin. The fixed joint has two large teeth, and a row of smaller reaching nearly to the anterior end. On the movable joint is one large tooth near the middle and a few serrations reaching to the anterior end. The patellar joint of the palp is shorter than the tibial, and has a lateral process at the anterior end.

The legs have no spicules on the trochanter, but short strong spicules on the femoral joint, and a few weaker spicules on the patella.

I am unable to distinguish the sex without damaging the single specimen.

The measurements in millimetres are as follows :—

	Length.	Breadth.
Cephalothorax	2½	2½
Abdomen	2	2½

	1st Joint.	2nd Joint.
Mandibles	7	8

Legs,—	Coxæ.	Tr. and Fem.	Pat. and Tib.	Met. and Tars.		
1	2	6	7	18	=	33
2	2	12	12	24	=	50
3	2	6	7	18	=	33
4	2	9	10	24	=	45
Palpi	—	3	3	3½	=	9½

One specimen, from Stewart Island. Named after Professor C. Chilton, of Canterbury College.

Genus PANTOPSALIS, E. Simon.

Pantopsalis. E. Simon, Comptes Rendus de la Soc. Ent. de Belgique, Mai, 1879, p. 16; W. Sorensen, Arach. Austr., Zweiter Theil, 1886, p. 56; Dr. J. C. C. Loman, Zool. Jahrb., Band xxi, 1902; R. I. Pocock, Proc. Zool. Soc., Dec. 2, 1902, p. 392, and Ann. & Mag. Nat. Hist., ser. 7, vol. xi, May, 1903, p. 436.

Pantopsalis trippi, Pocock.

I have compared this single specimen with Mr. Pocock's type specimen (in the British Museum Nat. Hist. Dept.) from Timaru, and it is certainly the same; the only difference being that in this there are short fine bristles on the eye-tubercle and in front of same, in his they are more definite spicules.

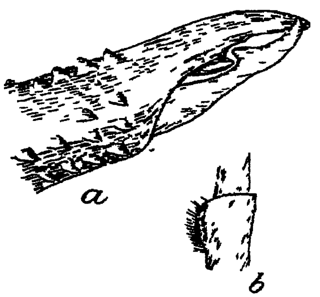

FIG. 4.—PANTOPSALIS TRIPPI.
a. Mandibular finger. b. End of tibial joint of palp.

The coxa, femur, patella, and tibia of the palp are orange, the long metatarsal joint being nearly white. The patella and tibia of same are of equal length. The anterior end of the patella has a sort of pad, covered with short bristles, instead of the process in the genus *Macropsalis* above detailed from the same locality, and the fingers are shorter, with one large tooth about the middle.

The measurements in millimetres are as follows :—

	Length.	Breadth.	
Cephalothorax	3	3	
Abdomen	—	—	(missing).

	1st Joint.	2nd Joint.		
Mandibles	10	11	=	21

Legs.—	Coxæ.	Tr. and Fem.	Pat and Tib.	Met. and Tars.		
1	2	7½	6½	16	=	32
2	2	—	—	—		
3	2	6½	6	18	=	32½
4	2	10	8	24	=	44
Palpi	—	3	2	3	=	8

One specimen, from Stewart Island.

In addition to the six species of *Pantopsalis*, all from New Zealand, detailed by Mr. Pocock (*loc. cit.*), there is in the British Museum collection a dried specimen from Tasmania, and broken parts of two more of the same, apparently undescribed. This extends the range of the genus farther than had been hitherto recorded. The Tasmanian species is lighter in colour, but not very different from the above. For the sake of comparison I append the description.

Pantopsalis tasmanica, nov. sp.

Carapace and legs rather dark yellow-brown.

The femoral, patellar, and tibial joints of the palpi yellow blotched with grey, the distal joint pale yellow.

The carapace and low eye-tubercle are quite smooth, without spines or granulation.

The mandibles are long and thin, the spinous tubercles thereon small but thickly spread over the whole surface of both joints. The first joint is slightly thickened at each end. The second, which is longer and stouter, gradually thickens slightly from the base to the anterior end. The point of the movable finger crosses that of the fixed one. The fingers are short, with one large tooth in the middle of each.

The palpi are fine and smooth, and shorter than the first joint of the mandibles. The patella and tibia are of equal length, and the anterior end of the former is just slightly thickened.

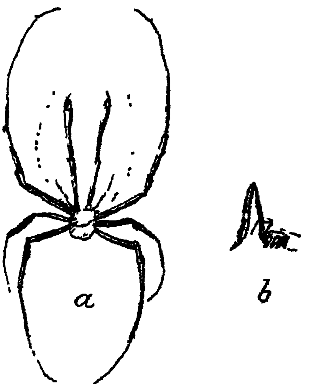

FIG. 5.—PANTOPSALIS TASMANICA.
a. Natural size. *b.* Profile.

The measurements in millimetros are,—

	Length.	Breadth.		
Cephalothorax	2	2		
Abdomen	—	—		
	1st Joint.	2nd Joint.		
Mandibles	7	8	=	15

Legs,—	Tr. and Fem.	Pat. and Tib.	Met. and Tars.		
1	—	—	—		
2	7½	8	17	=	32½
3	4½	4	8	=	16½
4	6	6	14	=	26
Palpi	1½	1½	2	=	5

One dried specimen in the British Museum (the abdomen and front pairs of legs missing), and parts of two others (smaller), one with much shorter but similar-shaped mandibles. This might be a sexual or age difference, but it is impossible to distinguish the sex of any of them.

Triœnonyx testaceus, nov. sp.

Carapace orange. Eye-tubercle yellow, with two black patches between the eyes. Mandibles pale yellow. Abdomen orange, transversely striped with black on the posterior segments. Legs very pale yellow.

The carapace, including the ocular tubercle, which is quite terminal, is very finely granulated, almost smooth, and with no tubercles or spines. The eyes are yellow, and situated nearly at the apex of their tubercle. On the upper side of the abdomen there is a transverse row of fine spines on each segment. On the under-side the segments are finely granulated and without tubercles.

The mandibles have the first joint smooth, the second with a median row of spinous bristles down the front and spines round the anterior margin; the fingers just cross one another at the points.

Palpi: The coxa has two large spinous tubercles on the under-side. The trochanter has one similar. The femur has on the under-side two large spinous tubercles at the base and one small about the middle, on the upper side a median row of small tubercles and red mottlings on the yellow ground. The patella is smooth. The tibia has two long spinous tubercles on the inner side and one short one in front. The tarsus has two inner and three outer spines.

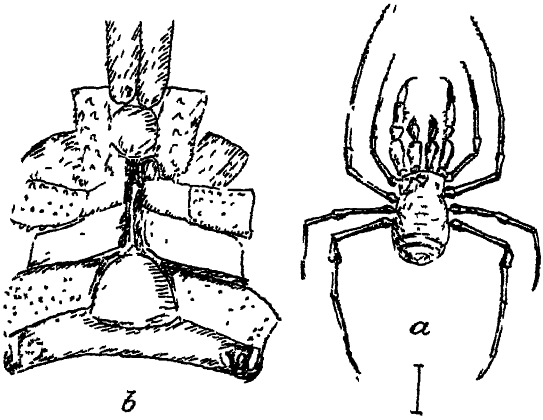

Fig. 6.—Triœnonyx testaceus.
a. Enlarged; ×2. *b.* Sternal and coxal area of under-side of thorax.

The coxæ of the first pair of legs have two large spinous tubercles on the under-side, and there are smaller spinous tubercles on those of pairs 2 and 3.

The maxillary process at the base of the second leg is double, the inner segment being twice as high as the other. The tarsal segments are 4, 10, 5, 5.

The measurements are as follows, in millimetres :—

		Length.	Breadth.		
		6	4		
		1st Joint.	2nd Joint.		
Mandibles		2	1½	=	3½
Legs,—	Tr. and Fem.	Pat. and Tib.	Met. and Tars.		
1	3	3	3	=	9
2	4	4	6	=	14
3	3	3	3½	=	9½
4	4	4	5	=	13
Palpi	2½	2½	1½	=	6½

This species is near to *T. sublævis*, Pocock. But. apart from the colour, which might possibly be a matter of age, it differs in the length of the end part of the single maxillary process, which is in this twice as high as in the other. The palp also is shorter, and the bespining of same different.

One female (?) labelled " New Zealand " only.

Triœnonyx stewartius, nov. sp.

Dorsal surface of carapace dark yellow-brown, lighter yellow-brown along the posterior edges of the segments ; under-side lighter yellow-brown. Legs dark brown mottled with yellow ; palpi, coxa, and trochanter yellow ; femur black-brown with round yellow spots, bright yellow at anterior end ; patella yellow ; tibia black-brown at basal half, anterior portion bright yellow ; distal segment bright yellow. Mandibles black-brown, fingers yellow.

The *carapace* is finely granulated. without spines or tubercles except as mentioned below. The anterior area of the upper surface is two-thirds as deep as the remainder. The eye tubercle is quite on the anterior edge, finely granulated, but without tubercles or spines. It is conical and low, and the eyes are situated almost at the apex.

There is a row of tubercles in front of the posterior border of the scute, and a few short bristles on the median line.

Palpi.—On the coxal joint there is 1 short spinous tubercle at the anterior end.

On the trochanter, 1 above and 1 each side.

On the femur, 3 large and 1 small above, 3 small on the inner side and 3 below.

On the patella, none.

On the tibia, 2 each side and 1 underneath at rear end.

On the tarsus, 3 on the outer side and 2 on the inner, with slightly curved yellow claws at the end.

On the palpal coxæ, and coxæ of 1st, 2nd, and 3rd pairs of legs, are rather large granulations. That of 4 is nearly smooth. The maxillary processes on the coxæ of the second pair of legs are single and roughly triangular.

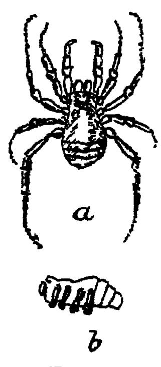

Fig. 7.
Triœnonyx stewartius.
a. Enlarged; × 2.
b. Profile.

The measurements in millimetres are as follows :—

	Length.	Breadth.
Carapace	3½	3 (2 in front).
Abdomen	1½	3

Legs,—	Tr. and Fem.	Pat. and Tib.	Met. and Tars.		
1	1½	1½	2¼	=	5¼
2	2	2	4	=	8
3	1½	1½	2	=	5
4	2½	2½	3½	=	8½
Palpi	1¼	½, ¾	1	=	3½

The tarsal divisions of legs are 4, 11, 5, 5,

This specics is rather close to *T. coriacea*, Poc., from Auckland ; but the legs are shorter in proportion and the bespining of the palpi is rather different, there are no tubercles on the abdominal segments, and the tarsal divisions of the legs are greater in number.

One male, from Stewart Island.

APPENDIX.

The following descriptions are reprinted here for the benefit of students in the Dominion who may not be able to consult the original works.

White, Proc. Zool. Soc. Lond., vol. xvii, 1849, p. 6.

PHALANGIUM LISTERI.

Chelicera enormously long ; first joint not quite so long as the second, and, like it, rough with outstanding short spines ; the end very slightly thickened, with two claws, one fixed, with a small tooth inside near the base, followed by a deepish notch, the movable claw with a largish tooth about the middle which fits into the notch of fixed claw.

Hab.—New Zealand.

M. Eugene Simon, Soc. Ent. de Belgique, Comptes Rendus, 2 May 1879, p. 16.

Genus PANTOPSALIS, nov. gen.

(Παν = totus, ψαλις = forfex.)

Teguments sub-coriacés. Corps tres-court, presque arrondi. Abdomen plus court que le cephalothorax ; celui-ci très élevé, presque conique.

Mamelon oculaire élevé, plus large que long, inerme, largement separé du bord anterieur. Chelicères d'une longueur excessive, plus de quatre fois plus longues que le corps, leurs deux articles presque égaux, doigts robustes et courts. Pre-epistome très grande trapezoide, epistome plus petit, en triangle avec le sommet un peu saillant et conique, mais non en forme de lame.

Lobos maxillaires de la seconde paire, cylindriques, attex, grêles, non attendués, et obtus, dirigés obliquement en avant mais ne se rencontrant pas. Avance sternale de l'abdomen un peu élargie en avant et tronquée. Piece anale petite, semi-circulaire, à peine aussi large que les bords reflèchis du 8 segment. Patte machoire beaucoup plus court que les chelicères, patelle et tibia beaucoup plus longs que larges, presque d'égale longueur, sans brosse interne, griffe tarsale très petite. Pattes très-longues et fines, tibia de la seconde paire et metatarses des 4 paires pourvus de fausses articulations.

Ce genre est le plus singulier de la famille des *Phalangidæ*, par des énormes chelicères ayant plus de quatre fois la longueur du corps, il rappelle même avec exaggeration, le genre *Ischyropsalis*, ses principaux caractères le rapprochent du genre *Gagrella*, Stol.

Type, *Pantopsalis listeri*, White. Proc. Zool. Soc., part xvii, 1849, sub. *Phalangium*.

Long., 5 mm.; chel. long., 25 mm. Nouvelle-Zélande (Île du Milieu).

Le Muséum du Paris posséde trois exemplaires rapportés par M. Filhol.

Corps très noir finement chagriné, portant sur le bord anterior un groupe de petits denticules irregulières.

Chelicères noires, doigts courts très robustes pourvus chacun d'une forte dent médiane.

Pattes noire cylindriques, femur garnis de petits denticules irregulières. Patte Machoire blanc testacés avec le fémur brun-rouge.

M. Simon (Zoologischen Jahrbuchern, vol. xxi. pt. 4, 1905) gives the following list of spiders as having been recorded from the Chatham Islands:—

Tegenaria domestica, Clerck (probably introduced).
Theridion tepidariorum, C. Koch (probably introduced).

Tetragnatha gulosa, L. Koch	New Zealand also.
Araneus verrucosus, Walckenaer	
Clubiona peculiaris, L. Koch	
C. cambridgei, L. Koch	
Desis marinus, Hector	
Cambridgea antipodiana, White	
Lycosa hilaris, L. Koch	
Amaurobius chathamensis, E. Simon	From Wharekauri Island, Chatham Islands, and peculiar to the locality.
Ariadne barbigera, E. Simon	
Clubiona chathamensis, E. Simon	
Mynoglenes (nov. gen.) *insolens*, E. Simon	
Dolomedes schauinslandi, E. Simon	
Lycosa ralphi, E. Simon	
L. turbida, E. Simon	
L. retiruga, E. Simon	
L. algida, E. Simon	

To these I added (Proc. Zool. Soc. Lond., 1908, p. 340 *et seq.*), from Pitt Island,—

Dolomedes huttoni, nov. sp.
D. trippi, nov. sp.

Art. XXXIV.—*On the Aeration of the Auckland Lava-beds.*

By James Stewart, M.Inst.C.E.

[*Read before the Auckland Institute, 22nd November,* 1909.]

About forty years ago the writer had the honour of reading before this Institute a paper describing certain lava caves at Three Kings, near Auckland.* In that paper, *inter alia*, reference was made to the fact that in the main pair of caves, upper and lower, currents of air were at all times observed blowing inwards from the outer air, and on one occasion, when a stiff breeze was blowing outside, the draughts were so strong in the more contracted places that the candles used for marking the main points of the traverse lines guttered and wasted away in a very short time. These currents were observed through the whole ramifications of the caves, and even at the extreme ends or in side chambers the flame of a candle showed decided draughts into the more open beds of the lava. Only in one place—viz., where the innermost end of one cave was found to overlap the position of another—was any outward draught observed. As the entrance to the main pair of caves at Three Kings is of considerable area—about 80 square feet, in fact—the velocity indicated that a very large volume of air passed inwards; and, although to the writer and his friend the late Mr. T. Kirk, F.L.S., who was one of the exploring party, the phenomenon was unexpected, no great importance was attached to it, as it was natural to suppose that the circulation would be quite local, and quickly diffused upwards through the more open patches of the rocky crust.

Two years ago, however, the significance of this terrestrial circulation of air was very forcibly called to the writer's notice. In the work of drainage of the Epsom depot of the Auckland Electric Tramways, situated 265 ft. above sea-level, he had occasion to extend the depth of a drainage-pit, sunk some years previously after consultation with the then Health Officer of the district. It was found, however, to be better to construct a new pit alongside the first one, which terminated in rock not sufficiently fissured to carry off the greatly increased amount of drainage from the septic tanks, &c., of the depot and adjacent show-grounds. The new pit passed through 19 ft. of rich volcanic soil, then through 7 ft. of slightly fissured but very hard bluestone lava. At the depth of 26 ft. a very open stratum of yellowish-brown scoria gravel of large size was struck, and opened out for about 2 ft. in depth. From this gravel a strong draught of pure fresh air was blowing into the pit. So strong was the current that a match could not be struck and lighted in it, and the workmen stated that a candle could not be kept alight in the strongest part of the draught. The indraught, as observed and noted by the writer, was strongest from the south-west, or from the direction of the Three Kings Hills, about a mile distant, but it extended with varying force more or less round fully one-half of the circumference of the pit. This inblast of air steadily continued until the pit was finished and put into use.

As these drainage-pits have become very common of late years in the scoria lands, the writer set about inquiries as to whether or not such an indraught had been observed before. He found that it had, especially in the Mount Eden district, and that sometimes the current was reversed, or from the pit into the scoria, the smoke from the blasting-powder clearing out of the pit with a downdraught. In a drainage-pit which has lately been sunk in the Township of Grand Park, a mile south-east from the Epsom depot, a band of loose rock was passed through, from which a decided draught of air came into the pit, but in volume not to be compared with that experienced at the Epsom depot.

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* Trans. N.Z. Inst., vol. ii, p. 162.

The facts as above stated seem sufficient to warrant the conclusion that all the permeable mass of the volcanic formation in the County of Eden is subject to constant aeration. From a sanitary point of view, the significance of this fact cannot be overrated. It seems to afford a satisfactory reason to account for the continued purity of the western and Onehunga springs, notwithstanding the fact that Onehunga has been settled for about sixty-two years, and Mount Eden district for about forty-five years. The population of the volcanic lands of Onehunga, Epsom, Mount Eden, and One Tree Hill at last census was 14,970, settled on an area in which there is not a yard of surface stream in the ordinary sense of the term, and up to the present no system of drainage excepting that of natural or artificial drainage-pits. On these volcanic lands at least three-fourths of the rainfall sinks into the ground, and certainly one-half passes into the vast mineral sponge, which term correctly describes the volcanic formation of the isthmus. The rainfall carries with it all sewage and liquid waste, and, if no purifying reaction existed, the effluent at the springs would long ere now have been quite unfit for domestic use. Without going into the records of chemical and bacterial testing, the particulars of which are not at the writer's command, it is sufficient to observe that the water yielded by the Onehunga springs maintains in all essential points the same high standard as from the first.

It must not, however, be deduced from this that it would be wise to trust to a continuance of the purity of the springs, without a regular system of drainage, at Onehunga, where a very considerable area of the crust is comparatively shallow, and where an accidental exposure of any of the larger fissures or cavities in the rock might lead to direct and rapid pollution. It must have been from some such cause that nearly fifty years ago the writer saw the main spring in Onehunga discharging in full volume red muddy water. But so long as the aeration as observed in the higher parts of the isthmus continues, the many millions of cubic yards of permeable strata which form the gathering-ground of the springs can be considered as nothing less than a gigantic aerobic filter, in which the soakage from such as the Epsom depot anaerobic tanks cannot flow more than a few hundred yards before it is thoroughly oxidized and rendered fit to mingle with, and be carried by, the discharge of that vast mineral sponge at the two great main springs and the numerous smaller ones that flow from the lava-beds which border high water on both shores of the isthmus.

ART. XXXV.—*Additions to the Terrestrial* Isopoda *of New Zealand.*

By CHARLES CHILTON, M.A., D.Sc., F.L.S.

[Read before the Philosophical Institute of Canterbury, 1st December, 1909.]

IN the year 1901 I published in the "Transactions of the Linnean Society" an account of the terrestrial *Isopoda* of New Zealand. Since then numerous additional facts have become known, and some additional species have been found; moreover, during the interval several important works dealing with certain sections of the group have appeared. It seems desirable, therefore, to collect this additional information together for the advantage of future workers. In some of the genera a thorough revision of the species is necessary; but this would entail more time than can be devoted to the matter at present, and I must content myself with merely indicating some of the questions that require solution. For the same reason descriptions of some new species are held over.

The list published in 1901 contained twenty-seven species in thirteen genera, only three or four being uncertain species. Included in the list, however, were three species which are now known to have been accidentally introduced by man, and which must therefore be omitted from the list of New Zealand species. These are *Porcellio scaber*, Latr., *Metoponorthus pruinosus*, Brandt, and *Armadillidium vulgare*, Latr. *Porcellio scaber* is extremely common all over New Zealand, and has spread far from inhabited places, though it has not often been found actually in the native bush. Of *Metoponorthus pruinosus* I (1905, p. 431, and 1906A, p. 64) have had specimens only from Rissington, in Hawke's Bay, though a specimen had apparently been gathered in New Zealand before 1847, for it was included in White's list published in that year, and was afterwards described by Miers under the name *Porcellio zealandicus*; *Armadillidium vulgare* is common in the town of Nelson, and I have one specimen from Mount Egmont, and more recently specimens from a garden at Sumner, Canterbury: but neither of the last two species appears to have spread in New Zealand in the same way as *Porcellio scaber* has done.

A few additional species have been added to the list of those found in the New Zealand region, from specimens gathered in the subantarctic islands to the south of New Zealand—viz., *Scyphoniscus magnus*, Chilton, *Haplophthalmus australis*, Chilton, *Trichoniscus magellanicus* (Dana); while *Oniscus novæ-zealandiæ*, Filhol, proves to be a separate species of *Deto*, and not identical with *Deto aucklandiæ*, as I previously thought it might be.

In a paper published at Copenhagen in 1904 Budde-Lund has given a revision of the *Spherilloninæ*, and in the genus *Spherillo* he includes a large number of species from New Zealand, Polynesia, and elsewhere which were previously included under *Armadillo*, while he also describes some new species from New Zealand under different genera of the subfamily. I do not fully understand the characters by which Budde-Lund separates *Spherillo* from *Armadillo*, and, as there is some doubt whether the name *Spherillo* is available for the use Budde-Lund makes of it, I give the species under *Cubaris*, a name that has priority, and has already been used by Stebbing (1900, p. 649) for species which apparently would be placed under *Spherillo* by Budde-Lund. In his paper Budde-Lund describes several new species from New Zealand based on specimens collected by Mr. Suter and others and sent to various European museums. I am by no means certain that all of these new species can be upheld as distinct; but, pending further investigation, I give them in the list below.

In his report on the terrestrial *Isopoda* collected by the German Antarctic Expedition, Budde-Lund (1906) has given an account of the genus *Trichoniscus*, taking it, however, to include *Titanethes, Haplophthalmus,* &c., which perhaps should be considered as separate genera. He divides this large genus into several subgenera, of which *Trichoniscus* is one, and this subgenus is further divided into groups according to the character of the eyes. The European species of *Trichoniscus* that are found habitually or occasionally in caves have more recently been investigated and very fully described by Racovitza (1907 and 1908), who also divides the genus into subgenera, though his divisions do not agree in all points with those suggested by Budde-Lund. It is evident that a thorough revision of the New Zealand species of this group is desirable, for until this is done I cannot arrange them in the subgenera suggested by Racovitza. In the present volume (p. 190) I describe a new species of *Trichoniscus* that is found in ants' nests, though some of the specimens probably live independently of the ants.

When the necessary changes and additions have been made, it is seen that the list of terrestrial species now numbers forty, included in twelve genera.

I give below a list of all the species now known from New Zealand, with additional information where this is necessary. Budde-Lund in 1904 has given a reclassification of the *Oniscidæ*, but at present I merely give the species in order, without attempting to arrange them in accordance with Budde-Lund's suggestions.

REVISED LIST OF THE TERRESTRIAL ISOPODA OF NEW ZEALAND, WITH NOTES ON NEW LOCALITIES, ETC.

(Only the more recent references have been given.)

Ligia novæ-zealandiæ, Dana.
Chilton, 1901, p. 107.

One specimen was taken in 1907 at Port Pegasus, in Stewart Island, the most southerly locality yet recorded for this species.

Trichoniscus phormianus, Chilton.
Chilton, 1901, p. 115; Budde-Lund, 1906, p. 83.

Trichoniscus otakensis, Chilton.
Chilton, 1901, p. 117; Budde-Lund, 1906, p. 83.

Trichoniscus thomsoni, Chilton.
Chilton, 1901, p. 118, and 1909, p. 661; Budde-Lund, 1906, pp. 83, 84.
Occurs on Auckland Islands, as well as on mainland of New Zealand.

Trichoniscus magellanicus (Dana).
Budde-Lund, 1906. pp. 83, 84; Chilton, 1909, p. 661.

Occurs on Auckland and Campbell Islands; also Tierra del Fuego and Falkland Islands. Perhaps identical with *T. verrucosus*, Budde-Lund, from the Crozets.

Trichoniscus commensalis, Chilton.
Described in the present volume, p. 190. A species found in ants' nests.

Haplophthalmus helmsii, Chilton.
Chilton. 1901. p. 119; Budde-Lund, 1906, p. 82.

Haplophthalmus australis, Chilton.
Chilton, 1909, p. 662.

Common on Campbell Island. The two species here placed under *Haplophthalmus* differ in one or two small points from the characters of the genus as given by Sars.

Tylos neozelanicus, Chilton.
Chilton, 1901, p. 120; Budde-Lund, 1906, p. 78.

Budde-Lund has recently reviewed the species of *Tylos*, but unfortunately is unable to add anything to our knowledge of *T. spinulosus*, Dana, from Tierra del Fuego, a species which is probably allied to *T. neozelanicus*.

Scyphax ornatus, Dana.
Chilton, 1901, p. 123.

Deto aucklandiæ (G. M. Thomson).
Scyphax (?) *aucklandiæ*, Chilton, 1901, p. 126 (in part); *Deto magnifica*, *D. robusta*, and *D. aucklandiæ*, Budde-Lund, 1906, pp. 86, 87; *Deto aucklandiæ*, Chilton, 1909, p. 666.

Known from the Auckland Island group only.

Deto novæ-zealandiæ, Filhol.
Chilton, 1906B, p. 273, 1909, p. 667; Budde-Lund, 1906, p. 87.

Chatham Islands (Miss Shand); Port Pegasus, Stewart Island (W. B. Benham). Recorded also from Wellington by Filhol.

The forms recorded from Chili under the names *Oniscus bucculentus*, Nicolet, and *O. tuberculatus*, Nicolet, are male and female either of this species or of one closely allied.

Scyphoniscus waitatensis, Chilton.
Chilton, 1901, p. 128.

The type specimens were obtained on the shores of the tidal lagoon at Waitati. I have since taken it on the shores of the Heathcote Estuary, and at Anita Bay, Milford Sound.

Scyphoniscus magnus, Chilton.
Chilton, 1909, p. 665.

On shores of Auckland and Campbell Islands.

Actæcia euchroa, Dana.
Chilton, 1901, p. 130.

Actæcia opihensis, Chilton.
Chilton, 1901, p. 132.

Originally taken on Timaru beach; since found on Quail Island, Lyttelton Harbour.

Oniscus punctatus, G. M. Thomson.
Chilton, 1901, p. 133, 1909, p. 668, and 1906B, p. 273.

Occurs on Chatham Islands and Auckland Islands, as well as on the mainland of New Zealand.

Oniscus kenepurensis, Chilton.
Chilton, 1901, p. 135.

Oniscus cooki, Filhol.
Chilton, 1901, p. 135.

I do not know this species.

Philoscia pubescens (Dana).
Chilton, 1901, p. 136 (in part).

According to Budde-Lund (1904, p. 43), two species were included by me in 1901 under this name—viz., *P. pubescens* (Dana), and *Pseudophiloscia fragilis*, Budde-Lund (see below). *Philoscia pubescens* (Dana) seems to be very near to *P. mina*, Budde-Lund, and to *P. hirsuta*, Budde-Lund, both from Cape Town (see Budde-Lund, 1906, p. 89). *P. mina* has been recorded by Dollfus from the Seychelles. A comparison of specimens from the different localities is much needed.

Philoscia novæ-zealandiæ, Filhol.
Chilton, 1901, p. 138.

I do not know this species.

Pseudophiloscia fragilis, Budde-Lund.
Budde-Lund, 1904, p. 43, pl. vi, figs. 5, 6.

Budde-Lund includes in this species the specimens from Howick, Auckland, which I had referred to *Philoscia pubescens* (Dana). He places *Pseudophiloscia* under the *Spherilloninæ*, and *Philoscia*, Latr., under the *Oniscinæ*.

Cubaris spinosus (Dana).
Armadillo spinosus, Chilton, 1901, p. 150; *Spherillo spinosus*, Budde-Lund, 1904, p. 54.

I have not seen this species.

Cubaris hamiltoni (Chilton).
Armadillo hamiltoni, Chilton, 1901, p. 148; *Spherillo hamiltoni*, Budde-Lund, 1904, p. 54.

Cubaris macmahoni (Chilton).
Armadillo macmahoni, Chilton, 1901, p. 149; *Spherillo macmahoni*, Budde-Lund, 1904, p. 56.

The type specimens were from Marlborough. Mr. W. W. Smith has since sent me specimens from New Plymouth.

Cubaris squamatus (Budde-Lund).
Spherillo squamatus, Budde-Lund, 1904, p. 61.

"One female specimen from Lyttelton, near Christchurch (Mus. Hamburg)."

Cubaris bipunctatus (Budde-Lund).
Spherillo bipunctatus, Budde-Lund, 1904, p. 62.

"One male specimen from Lyttelton (Mus. Hamburg)."

Cubaris ambitiosus (Budde-Lund).
Armadillo ambitiosus, Chilton, 1901, p. 144; *Spherillo ambitiosus*, Budde-Lund, 1904, p. 63.

This species is common all over the North Island, and in the South Island extends down the west coast as far as Daggs Sound.

Cubaris rufomarginatus (Budde-Lund).
Spherillo rufomarginatus, Budde-Lund, 1904, p. 64, pl. vii, figs. 34–36.

"One female specimen was taken at Taranga [? Tauranga] by Dr. Thilenius (Mus. Berlin)."

Cubaris marginatus (Budde-Lund).
Spherillo marginatus, Budde-Lund, 1904, p. 65.

"One female specimen taken from Auckland (Mus. Kjobenhavn)."

Cubaris rugulosus, Miers.

Armadillo rugulosus, Chilton, 1901, p. 147; *Spherillo rugulosus*, Budde-Lund, 1904, p. 65.

Occurs on the Auckland and Campbell Islands, as well as on the mainland of New Zealand.

Cubaris tarangensis (Budde-Lund).

Spherillo tarangensis, Budde-Lund, 1904, p. 67, pl. viii, fig. 9.

"At Taranga [? Tauranga] (Dr. Thilenius, in Mus. Berlin), at Lyttelton (Mr. Suter, in Mus. Hamburg)."

Cubaris monolinus (Dana).

Armadillo monolinus, Chilton, 1901, p. 148; *Spherillo aucklandicus*, Budde-Lund, 1904, p. 69.

Budde-Lund thinks this species is allied to *C. tarangensis.*

Cubaris speciosus (Dana).

Armadillo speciosus, Dana, 1853, p. 718, pl. 47, fig. 2, *a–d* (*not* Chilton, 1901, p. 146).

This species has not been re-identified with certainty.

Cubaris canaliculatus (Budde-Lund).

Spherillo canaliculatus, Budde-Lund, 1904, p. 74.

"Chatham Islands (Prof. Schauinsland, in Mus. Bremen)."

Cubaris chathamensis (Budde-Lund).

Armadillo speciosus, Chilton, 1901, p. 146; *Spherillo speciosus*, Budde-Lund, 1904, p. 75.

Budde-Lund establishes this species for the specimens from Chatham Islands that I had with hesitation referred to *Armadillo speciosus*, Dana. It appears to be a common species in the Chatham Islands, and is probably identical with the preceding species.

Cubaris setaceus (Budde-Lund).

Spherillo setaceus, Budde-Lund.

"Auckland, one specimen (Dr. B. Friedländer, in Mus. Berlin)."

Cubaris brevis (Budde-Lund).

Spherillo brevis, Budde-Lund, 1904, p. 93.

"Auckland (Mus. Dresden)."

With regard to the two species last mentioned, Budde-Lund says, "I have seen only one specimen of each of the two last species, many years ago, and the condition of them was not good, I therefore could not pay regard to the more essential characters, and their place here is not sure."

Cubaris danæ (Heller).

Armadillo danæ, Chilton, 1901, p. 145; *Spherillo danæ*, Budde-Lund, 1904, p. 94.

I have specimens from New Plymouth and from Kapiti Island in addition to the localities previously given.

REFERENCES.

Budde-Lund, G.

1904. "Revision of Crustacea Isopoda Terrestria: 2. Spherilloninæ." Copenhagen, 1904.

1906. "Die Landisopoden der Deutschen Südpolar Expedition, 1901–1903, mit diagnosen verwandten Arten." "Deutsche Südpolar Expedition, 1901–1903," band ix, Zoologie, 1, pp. 71–92.

Chilton, C.
1901. "The Terrestrial Isopoda of New Zealand." Trans. Linn. Soc., 2nd ser., Zool., viii, pp. 99–152.*
1905. "Note on the Distribution of some Species of Terrestrial Isopoda introduced into Australasia." Annals and Mag. Nat. Hist., ser. 7, vol. xvi, pp. 428–32.
1906A. "On the Occurrence of *Metoponorthus pruinosus*, Brandt, in New Zealand." Trans. N.Z. Inst., xxxviii, pp. 64, 65.
1906B. "List of Crustacea from the Chatham Islands." Trans. N.Z. Inst., xxxviii, pp. 270–73.
1909. "The Subantarctic Islands of New Zealand": Crustacea, pp. 601–71. Wellington. N.Z.

Dana, J. D.
1853. U.S. Explor. Exped.: xiv, Crustacea, ii.

Racovitza, E. G.
1907. "Isopodes terrestres (Première série)": Biospeologica, iv. Arch. de Zool. exp., 4ᵉ série, vii. pp. 145–225.
1908. "Isopodes terrestres (Seconde série)." *Loc. cit.*, ix, pp. 239–415.

Stebbing, T. R. R.
1900. "On Crustacea brought by Dr. Willey from the South Seas." "Willey's Zoological Results," part v, pp. 605–90.

ART. XXXVI.—*On the* Coleoptera *of the Kermadec Islands.*

By Major T. BROUN, F.E.S.

[*Read before the Auckland Institute, 22nd November*, 1909.]

THE beetles collected by the recent scientific expedition were received from Mr. W. L. Wallace, of Timaru, on the 3rd February, 1909.

Before proceeding with the result of my examination of the various species, it seems but right that some of the difficulties encountered by the members of the expedition should be recorded.

Denham Bay, with about 200 acres of level land, was selected as the most suitable site for the main camp. When starting on a collecting tour, an almost perpendicular wall, ranging from 800 ft. to 1,500 ft. in height, had to be ascended, each man having 30 lb. or 40 lb. weight of food, water, and other necessary articles strapped on his back.

When the crater was to be explored, there was a dangerous climb of 800 ft. along a winding track up the face of loose pumice formation, which was constantly slipping away from under their feet, the descent, on returning to the main camp, being even more hazardous. The huge crater, which now consists of undulating forest land and three lakes, was descended with the help of tree-roots.

The whole of Sunday Island is very rough, broken country, being almost everywhere a succession of steep, narrow ridges upwards of 1,000 ft. high, and intervening ravines, where, unfortunately, except in the crater, no water fit for drinking can be obtained.

The party took from Auckland supplies of flour, sugar, tea, salt, &c.; but for meat, goats had to be hunted, fish caught, and mutton-birds caught and preserved, occupations which, together with cooking, necessarily absorbed a considerable amount of time.

At first, many insects that had been captured under such unfavourable conditions were destroyed by ants and rats, which latter swarm to such an extent that it appears wonderful how they find enough food. One source of supply, no doubt, consisted formerly of the larger insects and grubs, as only a single specimen of moderately large size could be found during the ten months the expedition resided there.

I have endeavoured to make this memoir complete, not only by describing the novelties, but, without entering into minute details of generic structure, also giving such descriptions of exotic species as will enable them to be identified without referring to books which, unfortunately, are not procurable by students living in this Dominion. Those species that are also found in New Zealand, amounting to more than half of this collection, are included in the following list. With two or three exceptions their descriptions will be found in the "Manual of New Zealand Coleoptera." One, however, having been erroneously described in London under another name, has been fully redescribed.

LIST OF COLEOPTERA.

Group Carabidæ.

1. *Cylothorax insularis*, Motsch. Sunday, Macauley, and Curtis Islands, also in New Zealand.

Group Hydroporidæ.

2. *Bidessus plicatus*, Sharp. Sunday Island and New Zealand.

Group Colymbetidæ.

3. *Rhantus pulverosus*, Stephens. Sunday Island and New Zealand.

Group Hydrophilidæ.

4. *Philydrus tritus*. Broun. Sunday Island and New Zealand.

Group Staphylinidæ.

5. *Creophilus oculatus*, Fabr. Sunday Island and New Zealand.

Group Xantholinidæ.

6. *Xantholinus socius*, Fauvel. Sunday Island and New Zealand.

Group Omalidæ.

7. *Omalium fossigerum*, Fauvel. Sunday Island and New Zealand.

Group Carpophilidæ.

8. *Carpophilus vittiger*, Matth. Sunday Island and Polynesia.

Group COLYDIIDÆ.

9. *Pycnomerus sophoræ*, Sharp. Sunday Island and New Zealand.
10. *Coxelus xanthonyx*, Broun, sp. nov. Sunday Island.
11. „ *punctatus*, Broun, sp. nov. Sunday Island.

Group BRONTIDÆ.

12. *Cryptamorpha suturalis*, White. Sunday Island and New Zealand.

Group LATHRIDIIDÆ.

13. *Corticaria longula*, Broun, sp. nov. Sunday Island and New Zealand.

Group BYRRHIDÆ.

14. *Curimus zealandicus*, Redten. Macauley Island and New Zealand.

Group LUCANIDÆ.

15. *Mitophyllus curvidens*, Broun. Sunday Island and New Zealand.

Group APHODIIDÆ.

16. *Aphodius raoulensis*, Broun, sp. nov. Sunday Island.

Group ELATERIDÆ.

17. *Monocrepidius exsul*, Sharp. Sunday Island and New Zealand.
18. *Ochosternus zealandicus*, White. Sunday Island and New Zealand.

Group ENOPLIIDÆ.

19. *Necrobia ruficollis*, Fabr. Sunday Island, New Zealand; cosmopolitan.

Group TRACHYSCELIDÆ.

20. *Phycosecis atomaria*, Pascoe. Sunday Island and New Zealand.

Group SALPINGIDÆ.

21. *Salpingus lepidulus*, Broun, sp. nov. Sunday Island.

Group OTIORHYNCHIDÆ.

22. *Rhyncogonus planidorsis*, Broun, sp. nov. Sunday Island.
23. *Catoptes cheesemani*, Broun. Sunday Island.

Group CALANDRIDÆ.

24. *Sitophilus oryzæ*, Linn. Sunday Island and New Zealand; cosmopolitan.

Group CRYPTORHYNCHIDÆ.

25. *Acalles metrosideræ*, Broun, sp. nov. Sunday Island.
26. *Aldonus hylobioides*, White. Sunday Island and New Zealand.
27. *Rhyncodes saundersi*, White. Sunday Island and New Zealand.

Group COSSONIDÆ.

28. *Pentarthrum gracilicorne*, Broun, sp. nov. Sunday Island.
29. *Sericotrogus subænescens*, Wollaston. Sunday Island and New Zealand.

30. *Eutornopsis piceus*, Broun, gen. & sp. nov. Sunday Island.
31. *Dio dimorpha debile*, Sharp. Sunday Island and New Zealand.
32. *Microtribus sculpturatus*, Broun, sp. nov. Sunday Island.
33. *Phloeophagosoma dilutum*, Wollaston. Sunday Island and New Zealand.

Group PLATYPIDÆ.

34. *Platypus posticus*, Broun, sp. nov. Sunday Island.

Group EUMOLPIDÆ.

35. *Peniticus wallacei*, Broun, sp. nov. Sunday Island.

Group GALERUCIDÆ.

36. *Psylliodes solanæ*, Broun, sp. nov. Sunday Island.

Group COCCINELLIDÆ.

37. *Coccinella* 11-*punctata*, Linn. Sunday Island, New Zealand, Europe.
38. *Holopsis nigellus*, Broun. Sunday Island and New Zealand. (A specimen received from Mr. Wallace after this paper had been completed.)

The typical specimens are preserved in the Museum at Auckland.

Group COLYDIIDÆ.

Coxelus xanthonyx, sp. nov.

Robust, oblong, opaque, fusco-piceous, sides of thorax and the legs rufescent; with erect, yellow, coarse, but not squamiform setæ.

Head with indefinite granular sculpture. Eyes prominent and bearing some setæ externally. Thorax almost as long as broad, medially curvate in front: its sides slightly rounded and explanate, subcrenulate, slightly narrowed behind: base emarginated towards the sides so that the nearly rectangular angles do not touch the shoulders; the disc with 1 median impression and 2 indistinct basal ones, its granular sculpture well marked. Elytra oblong, without depressions, each with about 6 series of granules but not distinctly striate; there is a slight sutural elevation on the top of the posterior declivity.

Antennæ reddish, the club darker, basal joint concealed, 2nd large and thick, 3rd elongate, 4th and 5th longer than broad, 6–8 equal, 9th evidently broader than the preceding ones; 10th abruptly enlarged, transverse; 11th subrotundate, narrower than the 10th.

Tibiæ nearly straight, with shorter setæ than those on the dorsum, the tarsi with long slender setæ underneath the basal 3 joints, claws yellow.

This has been compared with each of its New Zealand allies, but does not agree with any of them. The central thoracic impression is broad. In most species the elytral sculpture is ill defined, so that series of punctures appear, when viewed in different directions, to be granular elevations.

Length, $1\frac{5}{8}$ lines; breadth, $\frac{5}{8}$ line.

Raoul Island.

One, found in decayed *Metrosideros* in the crater by Mr. W. L. Wallace.

Coxelus punctatus, sp. nov.

Oblong, opaque, piceous, legs and antennæ rufescent; with erect, pale-yellow, moderately coarse setæ, the tibiæ with shorter and finer setæ.

Head granulate. Thorax rather broader than long, its sides slightly rounded, only a little narrower behind than in front; with a linear median impression not reaching the base, near which there are 2 broad indefinite impressions, its granular sculpture is distinct. Elytra rather more convex behind than at the base, without depressions, their coarse punctures seriate but not deep or sharply marked, their lateral sculpture subgranular.

Antennæ rather short, their 1st joint hardly visible above, 2nd stout, 3rd elongate, the following two rather longer than broad, 6–8 small, 9th broader, 10th much broader, the terminal not as broad as its predecessor.

This is obviously smaller than *C. xanthonyx*. The sides of the thorax, though flattened, are less concave within the margins, and the elytral sculpture is entirely different. There is no similar species.

Length, 1¼ lines; breadth, ½ line.

Sunday Island.

One, also discovered by Mr. Wallace along with the preceding one.

Group Aphodiidæ.

Aphodius raoulensis, sp. nov.

Parallel, rather narrow, moderately transversely convex, nude; nigro-piceous, the legs and margins of head pitchy-red, antennæ and tarsi testaceous.

Head simple, rather closely and finely punctured behind, indistinctly in front, the frontal margin medially incurved. Thorax a fifth broader than long, subquadrate, slightly broader in front than at the base, which is as broad as that of the elytra, its sides slightly curved, anterior angles obtuse, the posterior rectangular but not projecting; the surface very irregularly and coarsely punctured, in front and on most of the intervals the punctures are much finer than those on the head. Scutellum narrow, elongate, and convex. Elytra strongly crenate-striate, the punctures near the sides more distinctly separated than those in the dorsal striæ; interstices with numerous minute punctures.

Underside shining, nigrescent, nearly smooth along the middle, flanks of mesosternum finely punctate, ventral segments with a transverse series of fine punctures at the base. Middle coxæ distant. Basal joint of posterior tarsi bare, hardly as long as the terminal tibial spurs, the intermediate joints bear yellow setæ.

Closely allied to *A. exsculptus*, the punctation of the thorax rather coarser, that of the elytra obviously so and more evidently crenate.

Length, 2¼ lines; breadth, quite ¾ line.

Raoul Island.

Found under rotten logs by Mr. Wallace. Apparently rare.

Group Salpingidæ.

Salpingus lepidulus, sp. nov.

Elongate, moderately transversely convex, shining; pubescence scanty, slender, suberect, and greyish. Head fusco-rufous, thorax cupreo-fuscous; elytra testaceous, but with the suture, and a large subovate spot just behind the middle of each, usually confluent with a lateral streak, dark fuscous; legs testaceous; antennæ fusco-testaceous, the terminal 4 articulations darker.

Head densely and minutely sculptured, rather dull, its punctation shallow, rather fine and moderately close. Eyes prominent. Antennæ elongate, basal joint stout, 3rd evidently longer than the contiguous ones, 2nd and 4th nearly equal and elongate, 5–7 elongate and oviform, 8–10 broader than the preceding, the terminal conical, the last 4 distinctly pubescent. Thorax cordiform, widest near the front, apex truncate, lateral margins obsolete; the surface distinctly, closely, and moderately finely punctured, rather more finely near the base. Scutellum broad. Elytra oblong, subparallel, curvedly narrowed posteriorly, slightly wider than thorax at the base; distinctly striate-punctate, their sculpture less distinct behind, the punctation of the sutural region, near the base particularly, irregular and closer.

Underside fuscous, the sternum and basal ventral segment coarsely, the remaining segments more finely, punctured, the terminal one fringed apically with fine grey pubescence.

Larger than *S. bilunatus*, with differently formed antennæ, the head and thorax relatively more finely punctured, &c.

Length, 1¼ lines; breadth, quite ⅜ line.

Raoul Island.

Several specimens brought by Mr. W. L. Wallace.

Group OTIORHYNCHIDÆ.

Rhyncogonus planidorsis, sp. nov.

Subovate, opaque, piceo-rufous, covered with depressed circular scales of a greyish colour.

Rostrum not longer than the head, marked off by a curved linear impression extending from the front of one eye to the other. Eyes obliquely oval, convex and prominent, more distant from each other than they are from the thorax. Scape stout, squamose, and bearing also erect greyish setæ like those of the funiculus, it reaches backwards to beyond the front of the thorax; 2nd joint of funiculus quite as long as the basal one, 3rd longer than any of the following four, which are submoniliform; club quadri-articulate, oblong-oval. Thorax about as long as it is broad, its sides rounded, narrower in front than behind, base and apex truncate, distinctly punctate. Scutellum small. Elytra subcordate, of the same width as thorax at the base, widest before the middle, much narrowed and declivous apically; disc rather flat, the 5th and 6th interstices are gradually and obtusely elevated from before the middle to the summit of the posterior declivity; they are regularly but not coarsely striate-punctate.

Legs squamositate and setigerous.

Underside punctate and squamose, and bearing also some fine setæ. Basal 2 ventral segments as long as the metasternum; 3rd and 4th nearly nude, short, with deep sutures; 5th closely punctured.

A rather small species, distinguished by the abbreviated rostrum and the somewhat flattened cordiform hind-body. The scrobes are short and deep, and quite open above. There are no ocular lobes.

Length (rostrum included), 2½ lines; breadth, 1⅛ lines.

Raoul Island.

One, captured by Mr. Wallace.

Group CRYPTORHYNCHIDÆ.

Acalles metrosideræ, sp. nov.

Convex, compact, subovate; much, but not at all abruptly, narrowed anteriorly; opaque; piceous, antennæ rufescent; densely covered with depressed variegated squamæ, and coarse erect greyish and slightly infuscate setæ; the sides for the most part are infuscate grey, but in unabraded specimens there is a whitish band across the top of the posterior declivity, the middle of the dorsum being brownish.

Rostrum slightly and gradually narrowed medially, squamose behind, rather closely rugose-punctate in front. Antennæ inserted behind the middle: the scape short and attaining the front of the eye, very gradually thickened; funiculus nearly twice the length of the scape, basal 2 joints very elongate, equal, 3–7 gradually decrease in length but are of nearly equal breadth; club ovate, its basal portion rather narrow. Eyes subtruncate in front. Thorax nearly as long as broad, widest near the subtruncate base, which is closely adapted to and of about the same width as that of the elytra; it is rather gradually narrowed, but not constricted anteriorly, its apex rounded; the surface is moderately finely and closely punctured; ocular lobes present. Elytra subcordate, widest near the middle; they are punctate-striate, the sutural 2 striæ are well marked and quite deep behind, the punctures oblong and distinctly separated, interstices moderately convex.

Legs long and stout, densely clothed; tarsi setose underneath, penultimate joint expanded and lobate.

Underside nearly plane, punctate and densely squamose. Pectoral canal deep, limited between the intermediate coxæ by the strongly elevated borders of the mesosternum. Metasternum short. Basal ventral segment large, quite a half longer than the next one, which is longer than the metasternum; 3rd and 4th short.

Somewhat variable, most specimens almost wholly obscure grey; two bear much darker fuscous scales, with the lighter parts tawny. In some a small scutellum is visible.

Length (rostrum exclusive), 1¾ lines; breadth, 1 line.

Raoul Island.

Found on *Metrosideros* by Mr. Wallace.

Aldonus, White. Man. N.Z. Coleopt., p. 482.

Body oblong-oval, moderately convex, squamose or setose.

Male.—Rostrum a fifth shorter than the thorax, its frontal portion slightly thicker than the basal. Scrobes deep, beginning between the apex and the middle, and extending to the front of the eyes, and with an apical prolongation. Scape moderately stout, very gradually incrassate, barely reaching the eye. Funiculus 7-articulate, 2nd joint rather longer than 1st, both moderately elongate; joints 3–7 gradually thickened, so that the transverse 7th is as broad as the base of the club, which is rather narrow, subovate, and indistinctly triarticulate. Head immersed nearly to the eyes, short and rounded. Eyes flat, their frontal or inner margin truncate. Thorax broader than long, contracted but not abruptly in front, the base bisinuate so that the obtuse angles rest on the elytra, the ocular lobes finely ciliated. Scutellum small and depressed. Elytra slightly wider than thorax at the base, humeral angles obtusely prominent.

Femora deeply notched near the extremity, and appearing medially angulate below. Tibiæ strongly uncinate. Tarsi with silky hairs underneath the basal 2 joints; the 3rd with short brushlike vestiture, much shorter and broader than the preceding ones, and evidently bilobed; the terminal joint of about the same length as the basal.

Pectoral canal deeper in front than it is between the coxæ, not extending into the mesosternum, being limited behind by the mesosternal lamina, which is broad and cordiform and medially concave in front in a reversed New Zealand specimen, but more deeply concave and sublunate in one from the Kermadec Islands. Metasternum between the middle and hind coxæ hardly longer than the 2nd ventral segment, which, at the sides, is but little shorter than the basal one; 3rd and 4th together quite as long as the 2nd. The mentum projects half-way into the buccal cavity, where the porrect 4-jointed palpi are clearly discernible.

Female.—Rostrum rather longer and more slender, subparallel, slightly dilated at the base. Scrobes well defined, starting just before the middle, and without any trace of subapical prolongation. Scape more slender and flexuous.

In my genus *Nothaldonus* the rostral canal is deep throughout and extends into the cavernous mesosternum, the sharply elevated borders of which are in contact with the anterior coxæ. The mentum is broader and the rigid palpi more prominent. The tarsal vestiture is more scanty, and the eyes more finely faceted. (See page 1235, Man. N.Z. Colept.)

Aldonus hylobioides, White.

Piceous, the derm slightly nitid, covered chiefly with greyish-yellow scales, but with a large lateral area behind the middle, and other ill-defined spots, bearing dark-fuscous squamæ; legs and antennæ more or less piceo-rufous.

Thorax closely rather coarsely and rugosely punctate, usually with a slightly raised smooth line along the middle; its sides moderately rounded but nearly straight though slightly narrowed behind, the apex only half the width of the base; it is broader than long. Elytra with indefinite sculpture, consisting apparently of 7 dorsal striæ or series of oblong punctures on each, the striæ more distinct behind; interstices uneven and asperate, usually with small granular elevations intermingled with the squamæ; they are slightly wider than the thorax at the base, with prominent shoulders; their sides are more or less gradually narrowed backwards, and cover the abdomen.

Legs with variegated scales and setæ, these latter finer and more hair-like along the inside of the tibiæ than those along the sides of the body.

Underside shining pitchy-black, irregularly and rather coarsely punctured, the yellowish scales thicker near the sides than along the middle, the terminal ventral segment rufescent and closely punctured.

Male.—Rostrum with longitudinal sculpture, subcarinate and grooved behind, punctate in front, more or less squamose.

Female.—Rostrum shining, reddish, finely punctured but appearing smooth.

Length (rostrum exclusive), 2½–5½ lines; breadth, 1–2⅛ lines.

Sunday Island.

Mr. Wallace states that the insect is common in rotten karaka and other timber. Having examined about twenty specimens, I have drawn up a more modern description than the original one. The subsequent discovery of allied genera in New Zealand renders redescription necessary.

Group Cossonidæ.

Pentarthrum gracilicorne, sp. nov.

Subdepressed, sparingly and minutely pubescent, moderately nitid; thorax nigrescent, its apex of a metallic coppery hue; elytra, legs, and rostrum piceo-rufous; the antennæ and tarsi paler red.

Rostrum rather shorter than thorax, parallel, or only indistinctly narrowed near the eyes, slender, finely punctate, nearly quite smooth along the middle. Occiput broad and convex above, distinctly marked off just behind the eyes from the narrow forehead; it is but little swollen underneath. Eyes only slightly prominent. Antennæ elongate and slender; scape inserted just behind the middle of the rostrum and reaching the back of the eye; it is incrassate near the extremity; 2nd joint of funiculus evidently longer than 3rd, the terminal 3 as long as broad; club ovate, indistinctly ringed. Thorax about a third longer than broad, constricted in front, its sides but little rounded, slightly and gradually narrowed anteriorly, base truncate; disc nearly plane, moderately closely but not coarsely punctured, more finely in front, and with an ill-defined median impression near the base. Scutellum small but distinct. Elytra slightly wider than thorax at the base, which is subtruncate, their sides subparallel, curvedly narrowed posteriorly; dorsum very slightly convex, almost crenate punctate-striate, the sutural 2 striæ on each deepest throughout; interstices finely seriate-punctate.

Legs normal; 3rd joint of the tarsi a little expanded and lobate.

Underside shining, entirely nigrescent, with some minute greyish hairs; distinctly but not closely or coarsely punctured, more sparingly on the basal 2 ventral segments, which are not visibly delimited; there are no impressions except the metasternal groove. The position of the coxæ is similar to that of *P. zealandicum*. Along the centre of the rostrum there is an almost smooth line which is gradually expanded behind, where it is divided by a broad groove; the buccal cavity also differs from that of *P. zealandicum*.

This is a rather small species, with the antennæ implanted a little further from the eyes, and more slender than in the female *P. zealandicum;* the rostrum is rather longer, the thorax is different in form, the smooth occiput is dissimilar, and the penultimate tarsal joint is more dilated and subbilobed. The discovery of the male will, I have no doubt, render generic separation necessary.

Female.—Length, 1⅝ lines; breadth, ⅜ line.

Raoul, Sunday Island.

Two examples taken from rotten ngaio wood by Mr. Wallace.

Eutornopsis, gen. nov.

Body transversely convex, subcylindric, nude above, finely pubescent underneath, moderately nitid, distinctly sculptured.

Head and rostrum slightly arched and, together, as long as thorax; he outline almost uninterrupted, there being only a slight inflation near he eyes; the former exserted, globose below, and with only a very slight post-ocular stricture; the latter as long and nearly as broad as the head, parallel, or only just perceptibly narrowed anteriorly, that of the male not appreciably different from the female. Scrobes deep, prolonged downwards along the front and lower part of the eyes. Scape rather short, medially inserted, attaining the back of the eye, strongly flexuous. Funiculus rather short, its 5 articulations transverse, the basal one somewhat larger. Club annulate, oval or oblong-oval. Eyes as far from each other as they are from the thorax, quite lateral, slightly prominent and rotundate. Thorax a little longer than broad, rather gradually narrowed anteriorly, without any definite constriction, the basal margin truncate and a little depressed. Scutellum rather small, but distinct. Elytra slightly wider than thorax at the base, very gradually and slightly narrowed backwards, with simple apical margins.

Legs moderately stout; tibiæ uncinate, the anterior acutely prominent at the inner extremity. Tarsi narrow, their third joint concave in front but entire underneath, unexpanded, the terminal one elongate and slender.

Prosternum straight in front. Anterior coxæ distinctly separated. Metasternum shorter than the abdomen.

The type of this genus has the aspect of *Eutornus*, one of the Cossonides, a circumstance which suggested its name. It departs from *Pentarthrum* by the much less distant front coxæ, by the different rostrum, head, and thorax, as well as by the strongly bent scape and slender terminal joint of the tarsi, and, moreover, the female in *Pentarthrum* is strongly differentiated from the male by her slender rostrum, differently shaped thorax, and different antennal insertion, whereas *Eutornopsis* presents no very obvious sexual characteristics.

Eutornopsis piceus, sp. nov.

Piceous, moderately shining, with a rufescent mark behind each shoulder, antennæ and legs piceo-rufous; the club and inner face of the front tibiæ bear yellow pubescence.

Rostrum distinctly and moderately coarsely punctured, its apical portion and the head more finely and distantly, the occiput smooth behind. Thorax broadest near the base but not very evidently dilated or rounded there; its punctation moderately coarse and close, but much finer in front. Elytra punctate-striate, the 2nd and 3rd striæ deepest near the extremity, the outer striæ indistinct, the punctures are somewhat transversal and distinctly separated from each other; interstices with fine distant serial punctures.

Underside shining, piceous, rather finely, not closely, and somewhat irregularly punctured, the basal ventral segment more closely than the metasternum, the 3rd, 4th, and 5th segments with deep sutures, 5th closely punctate and slightly impressed across the middle, the metasternum and basal 2 segments slightly flattened but not concave. The pubescence yellow and scanty. The rostrum has almost seriate punctures, but along each side of the middle there is an elongated smooth space.

Female: Rather larger, her rostrum very slightly longer and more finely punctate.

Length, 2¼–2¾ lines; breadth, quite ½ line.

Sunday Island.

Several specimens found by Mr. W. L. Wallace amongst decaying ngaio and karaka.

Microtribus sculpturatus, sp. nov.

Fusiform, sparingly clothed with very fine suberect grey hairs; moderately shining, piceous, apical margin of thorax slightly rufescent, antennæ and legs piceo-rufous.

Rostrum of about the same length as the thorax, moderately stout, slightly arched, parallel; distinctly, moderately finely but not closely punctured, more indistinctly in front, where there are some fine yellowish setæ. Head rather more distantly and finely punctate. Thorax longer than broad, its sides hardly at all rounded; rather closely and coarsely punctured, the intervals densely and minutely sculptured. Scutellum absent. Elytra elongate, subovate, slightly wider than thorax at the base, quite glossy; regularly and coarsely striate-punctate, interstices with fine distant punctures, closer alongside the suture than elsewhere.

Antennæ medially inserted, indistinctly pubescent, the rather narrow club more distinctly; scape slightly flexuous; 2nd joint of funiculus of nearly the same length as the basal one, joints 3–5 about as long as broad.

Legs pubescent, the inner extremity of the front tibiæ particularly; tarsi densely setose, their 3rd joint with well-developed lobes.

Underside nitid, piceous, coarsely punctured as far as the extremity of the 2nd ventral segment, the 5th more finely and closely but without depressions. Prosternum slightly emarginate. Anterior coxæ subcontiguous, the intermediate moderately, posterior widely separated. Metasternum and basal ventral segment broadly but not at all deeply impressed, 2nd segment indefinitely delimited in front.

Materially different from the typical species (*M. huttoni*) in appearance. The thorax rather larger, cylindric rather than ovate, and rather more coarsely and closely and slightly rugosely punctured. The elytra are a little narrower near the apex, and their coarser sculpture is continued to the extremity. This species, however, agrees structurally.

Length, 1½ lines; breadth, ⅜ line.

Sunday Island.

Found on the leaves of *Solanum* by Mr. W. L. Wallace. Only two specimens.

Group Platypidæ.

Platypus posticus, sp. nov.

Cylindric, rather slender, moderately shining, rufo-fuscous.

Thorax oblong, apex truncate, base medially angulate, each side incurved behind the middle and with a slight obtuse angulation there; its surface very finely and indistinctly punctate, with minutely sculptured intervals; there are a few larger, yet fine, punctures near the base, just in front of the latter, at the middle; there is a small fovea from which an indefinite linear impression proceeds forwards; it bears a few slender yellowish hairs. Elytra parallel-sided, base bi-arcuate; on each elytron there is a shallow basal impression near the middle, and a more slender one nearer the suture, which can hardly be termed striæ; along the disc 5 or 6 series of very fine punctures can be seen, the suture is depressed; near the extremity there are 6 or 7 deep grooves, on each the outer angle is distinctly dentiform and projecting, the suture slightly so, this posterior portion bears fine but obvious yellow pubescence. Pygidium nearly vertical, and only visible from behind.

Described from a single damaged specimen. Several were taken from the trunk of a dead nikau, but, unfortunately, made their escape by eating through the cork of the tube in which they had been placed. It is nearly as slender as *P. gracilis*, but with very different sculpture.

Length, 2¼ lines; breadth, ⅝ line.

Raoul Island.

Found by Mr. Wallace.

Group Eumolpidæ.

Peniticus wallacei, sp. nov.

Robust, shining, æneo-fuscous, head and thorax darker than the elytra, legs fusco-testaceous, tibiæ usually darker than the femora and tarsi, antennæ rufo-fuscous.

Head moderately finely and irregularly punctured, middle of occiput generally smooth and with a slight impression behind; it is immersed up to the moderately prominent subrotundate eyes. Labrum reddish. Antennæ longer than the head and thorax, pubescent, 2nd joint short and subglobular. 3–11 elongate and nearly equal. Thorax about a fourth broader than long, its base only feebly rounded or truncate; its sides well rounded, widest near the middle and obtusely prominent there, more straight-sided or feebly sinuate behind in the male; posterior angles rectangular, but scarcely acutely prominent, the anterior deflexed and acute; the surface irregularly, distinctly, but moderately finely punctured, basal and lateral margins distinct. Scutellum smooth, or with a single puncture. Elytra as wide as thorax at the base, moderately rounded; on each there is a distinct, somewhat curvate carina or plica at the base just outside the middle, and another near the side but distant from the base; these are testaceous. as are also, but less definitely, 2 or 3 of the interstices and the apical portion, sometimes there are 2 less obvious plicæ near the side; there are 3 or 4 striæ on each behind, these, however, do not attain the apex; the punctation is moderately fine, not quite seriate, closer near the base and irregularly duplicated near the middle; the intervals are minutely and densely sculptured.

Underside nitid, sparingly pubescent, æneo-fuscous, terminal ventral segment paler or rufescent, distinctly but rather finely and not closely punctate. Anterior coxæ rather less widely separated than in *P. suffusus*. Basal segment in the middle as long as the following three combined, 4th not medially abbreviated, almost the same length as the preceding one, 5th plane, longer than the intermediate ones, very scantily pubescent, with a well-marked foveiform apical depression.

Posterior tibiæ grooved near the extremity. Front tarsi with broad, subcordate basal articulations, 2nd narrow at the base, deeply emarginate at the apex, the 3rd with elongate and rather narrow lobes, claws thickened near the base but less dentiform than in the New Zealand species.

Female.—Ventral segments 4th and 5th somewhat violaceous, the former rather shorter than the 3rd, the 5th simple, basal segment longer than that of the male. Basal joint of front tarsi subtriangular.

Var. *a:* Elytra with one elevated basal plica on each elytron; this, as well as the base and apex, is more or less testaceous, but there are no pale discoidal streaks; the serial punctures hardly at all duplicated. Thorax more obtusely angulated laterally behind the middle, and therefore appearing more obliquely narrowed towards the slightly projecting basal margins. Terminal ventral segment with a deep fovea; the 3rd, however, is very slightly abbreviated in the middle.

Length, 2⅜–2¾ lines; breadth, 1⅛–1½ line.

Raoul Island.

Several specimens discovered under dead nikau leaves by Mr. W. L. Wallace, in whose honour I have named the species.

Group GALERUCIDÆ.

Psylliodes solanæ, sp. nov.

Compact, convex, oblong-oval, narrowed anteriorly, glabrous, nitid; viridescent, somewhat æneous; tibiæ and basal 3 or 4 joints of antennæ testaceous, the remaining joints slightly infuscate; posterior femora bronzed brown.

Head finely punctate, hardly as wide as front of thorax. Eyes large, obliquely oval. Thorax widest at the base, which is oblique towards the sides, posterior angles nearly rectangular; its sides almost straight, only slightly narrowed anteriorly, their margins fine, but in front very distinctly incrassate and oblique; it is moderately finely, distinctly, but not closely punctured. Scutellum smooth. Elytra oblong-oval, finely margined, the base as wide as that of the thorax, the shoulders smooth, sometimes very slightly raised; they are moderately striate-punctate, the striæ, however, are distinct at the sides only, the sutural series of punctures extend obliquely from the base to the middle, the posterior sculpture is irregular, the apices are separately broadly rounded or subtruncate, so that the terminal abdominal segment is usually exposed.

Underside shining, bronzed. Abdomen rather elongate, very convex transversely, rufo-fuscous, finely and sparingly punctate and pubescent; basal segment largest, somewhat hastate, and medially depressed, between the coxæ; 2–4 equal, 5th moderately elongate, truncate at apex, the supplementary conical and deeply concave. Prosternum short, the intercoxal process moderately broad and punctate. Mesosternum carinate and medially incurved in front. Metasternum shorter than the basal segment, convex, triangularly impressed behind, its frontal process triangular and with carinate margins between the coxæ.

Posterior femora strongly developed, very broad and subtruncate at the base but tapering backwards. Tibiæ, posterior, widely incurved, narrowed and broadly grooved near the extremity, this part minutely denticulate externally. Tarsi, the hind pair as long as the tibiæ, attached to these at some distance from the apex; their basal joint elongate, longer than the following three taken together, 3rd bilobed, claws simple.

Antennæ inserted at the front and inner margins of the eyes, reaching backwards to the middle of the wing-cases, 10-articulate; basal joint curvate, not much longer than either of the following two, 4–9 rather thicker than the preceding one, the 10th with a small apical articulation.

The distinguishing features of the genus, the only one in Lacordaire's group *Psilliodites*, are the 10-jointed antennæ, and peculiar tibiæ and tarsi, which I have described above. The species are numerous and widespread. None in my collection, from Europe and America, resemble this. The supplementary terminal articulation of the antennæ will serve as a good differentiating character.

Length, 1½ lines; breadth, ¾ line.

Sunday Island.

Found by Mr. W. L. Wallace on the common *Solanum*.

Group Carpophilidæ.

Carpophilus vittiger, Matt.

Elongate, subdepressed, the whole derm densely and minutely sculptured so as to appear subopaque, clothed with decumbent yellowish hairs; head and thorax fuscous, the front and back of the former, the sides and apex of the latter, somewhat rufescent; elytra obscure fusco-testaceous, the suture, apical portion, and an irregular discoidal area on each fuscous, the scutellum and the 2 uncovered abdominal segments also more or less infuscate; legs and antennæ fusco-rufous, the club darker.

Head nearly as broad as front of thorax, contracted behind the large, prominent, subrotundate eyes, its surface moderately finely and closely punctate. Thorax transversely quadrate, its sides distinctly margined, nearly straight, in some examples slightly rounded, its angles obtuse, base and apex subtruncate; its punctation rather finer than that of the head, not close, and on some parts indistinctly granulate, some specimens with a median linear space nearly smooth. Scutellum large, finely punctate or subgranulate. Elytra suboblong, of about the same width as the thorax at the base, their apices oblique towards the suture, their sides finely marginated and but little curved; their sculpture finely punctate or granulate according to the point of view. Abdomen with the first exposed segment transverse, the second longer and narrowed posteriorly, and, in male specimens, with a very small apical segment.

Underside moderately shining, dark fuscous, scantily pubescent, finely yet distinctly but not closely punctate. Prosternal process broad, finely grooved laterally, attaining the mesosternum. Coxæ nearly equally separated. Metasternum rather shorter than abdomen, medially grooved. Ventral segments unequal, 5th longest, subconical, the basal one rather longer than the 4th, 2nd and 3rd very short.

Femora moderately dilated, grooved underneath. Tibiæ gradually expanded towards the extremity, with distinct terminal spines. Tarsi 5-jointed, the basal 4 of the anterior dilated and, together, but little longer than the terminal one; the 4th of the posterior pair small.

Antennæ rather longer than the head, 11-articulate, basal joint large, dilated towards the apex, 2nd cylindric, 3rd slender, slightly longer than 2nd, 4–7 short, 8th obconical, slightly broader than 7th; club large, 3-jointed, but with an additional small, sometimes indistinct, apical appendage.

Length, 1½–2 lines; breadth, ½–¾ line.

Sunday Island.

Common in decaying oranges and bananas.

Obs.—The species are numerous and widely distributed. Another species (*C. hemipterus*) was found by me in different parts of Auckland. The allied genus *Brachypeplus* is represented by a species (*B. brevicornis*) which I discovered thirty years ago at Tairua, and in January, 1909, I again met with it on trees at Waimarino.

Group Enopliidæ.

Necrobia ruficollis, Fab.

Suboblong, moderately transversely convex, bearing short and elongate outstanding infuscate and yellowish-grey hairs; shining; thorax, base of elytra, and legs red; remainder of elytra and the head blue; antennæ nigrescent.

Head as broad as front of thorax, narrowed anteriorly, distinctly and somewhat irregularly punctured. Eyes large, prominent, coarsely faceted. Thorax about a fourth broader than long, widest near the middle, base finely margined and bisinuate, lateral margins minutely crenulate, its angles obtuse; disc distinctly but not closely punctate, the sides more closely. Elytra oblong, broader than thorax, evidently seriate-punctate, less distinctly at the base, the suture and interstices finely punctured.

Legs stout, hairy; femora rather short. Tarsi apparently only 4-jointed, the true 4th joint minute, yet discernible between the lobes of the 3rd, the 2nd and 3rd with membranous lamellæ underneath, terminal joint elongate; claws thickened at the base.

Antennæ 11-articulate, basal joint subpyriform, 2nd short, 3rd evidently longer than the contiguous ones, 5–8 short; club large, its basal joints strongly transverse, the terminal one about as long as the preceding two combined, subtruncate at the extremity.

Length, 2¾ lines; breadth, 1⅓ line.

Sunday Island.

The Bell family, on one occasion, dried a great quantity of sea-birds' eggs, which became a moving mass of this species. It is nearly cosmopolitan, and occurs in New Zealand amongst the bones and skins of dead animals, &c.

Group CALANDRIDÆ.

Sitophilus oryzæ, Linn.

Elongate, subovate, nearly plane above, subopaque: colour variable, piceous, fuscous or ferruginous, thorax darker than elytra, these latter with 4 reddish spots, 2 basal and 2 subapical; scantily clothed with short, erect, yellowish setæ, those on the legs paler.

Rostrum shorter than thorax, slightly arched, moderately stout, cylindrical, but somewhat dilated at the base, with longitudinal series of rather coarse punctures which almost form grooves. Scrobes short, basal, not visible above. Head rather short, conical, finely punctate behind, with an interocular depression. Eyes flat, strongly transverse. Scape stout, inserted at the dilated basal portion of the rostrum, extending backwards beyond the eyes. Funiculus much longer than the scape, 6-articulate, 2nd joint as long as the basal, 6th slightly larger than 5th; club oval, solid, but with a small, pubescent, apical appendage. Thorax a fifth longer than broad, gently narrowed anteriorly, abruptly contracted at apex, posterior angles rounded; coarsely, closely, and rugosely punctured at the sides, the middle of the disc more finely and less closely. Scutellum distinct. Elytra slightly longer than thorax, as wide at the base, gradually narrowed posteriorly, apices broadly rounded or subtruncate; the sutural region is somewhat depressed, they are evidently punctate-striate, with narrow interstices. Pygidium uncovered, vertical, with short, coarse setæ. Legs elongate; tibiæ with well-developed apical hooks, the inner extremity of the anterior acutely spiniform. Tarsi moderately elongate, their 3rd joint excavate above but not distinctly bilobed.

Underside closely and coarsely punctured, the basal ventral segment medially depressed.

Female.—Rostrum finely seriate-punctate.

Male.—Length (rostrum inclusive), 2 lines; breadth, ⅝ line.

Sunday Island.

Found in rice and flour; sometimes only too common at Auckland, where I saw it during 1866.

Group COCCINELLIDÆ.

Coccinella 11-punctata, Linn.

Compact, convex, broadly oval, glabrous, shining; head, thorax, and legs black, elytra testaceous or rufescent, all these, except the legs, maculate; antennæ pale fuscous.

Head narrower than thorax, closely punctate; the front margin of the forehead and 2 interocular spots pale yellow. Thorax strongly transverse, deeply emarginate in front, so that the anterior angles appear obtusely prominent: base widely rounded, with rounded angles; the sides slightly curved and narrowed anteriorly, their margins more distinct behind than in front: its surface closely and finely punctured, and with a large yellowish spot at each anterior angle. Elytra broader and much longer than the thorax, with rounded shoulders, lateral margins distinct, they are finely and closely punctate: at the middle of the base there is a large spot which is divided by the suture, there is a smaller one about as distant from each side as from the base, across the middle there are 4, and there are 4 others behind, all of which are black.

Legs with fine grey hairs. Tarsi apparently tri-articulate, the small true 4th joint, however, is visible within the excavation of the 2nd, which is quite the length of the basal one, the terminal is as long as the preceding two combined; claws thickened at the base.

Antennæ rather short and slender, 11-jointed, the basal 2 are thick, 3rd and 4th equal, moderately elongate, 5 to 8 decrease in length; the joints of the club gradually expanded, the terminal one broad and obtuse at the apex.

Underside black.

Length, 2¼ lines; breadth, 1½ line.

This valuable European ladybird is sometimes abundant in New Zealand. Two specimens were brought by Mr. Wallace from Macauley Island; in both the 4 median spots are transformed into 2. None were found on Sunday Island.

ART. XXXVII.—*Additions to the Coleopterous Fauna of the Chatham Islands.*

By Major T. BROUN, F.E.S.

[*Read before the Auckland Institute, 22nd November, 1909.*]

LIST.	GROUPS.
42. *Leperina shandi*, Broun	TROGOSITIDÆ.
43. *Lissotes dispar*, Broun	LUCANIDÆ.
44. *Aldonus misturatus*, Broun	CRYPTORHYNCHIDÆ.
45. ,, *lineifer*, Broun	,,

To these descriptions, owing to the kindness of Mr. Charles O. Waterhouse, of the British Museum, that of *Lissotes capito*, Deyrolle, has been added. This could not be obtained in New Zealand.

In my previous paper* all the then known *Coleoptera* are recorded, and the species numbered consecutively for convenience of reference, so that in correspondence the number only of each species need be quoted instead of the whole name. This convenient system is continued in the present list.

We are indebted to a lady, Miss S. D. Shand, of Te Whakuru, for the collection of interesting beetles enumerated above, and it is hoped she may continue adding to our knowledge of such insects, of which about a twentieth part only have been brought to light.

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* Trans. N.Z. Inst., vol. xli, 1908, p. 145.

Group Trogositidæ. Gen., Man. N.Z. Coleopt., p. 177.

Leperina shandi, sp. nov.

Elongate-oblong, subdepressed, slightly nitid; fusco-piceous, elytra sometimes rufescent; legs, antennæ, and palpi piceo-rufous; labrum and sides of thorax reddish; squamosity yellowish, depressed, and chiefly confined to the sides of the thorax, thicker and suberect on the elytra, which also bear numerous distinct erect setæ, their margins with slender, outstanding but short and rather indistinct setæ.

Head coarsely and irregularly punctured, and longitudinally rugose towards the front, it is almost or quite bald; the lateral protuberances in front of and below the antennæ well developed. Thorax 1½ lines long in the middle by 2⅛ broad, widest near the middle, slightly curvedly narrowed towards the prominent anterior angles, rather strongly sinuate-angustate behind, posterior angles rectangular, the lateral margins thick and reflexed, apex fringed with yellow hairs: the punctation very close and coarse, but becoming more distant towards the middle, and finer near the base and apex; its sides have small outstanding setæ. Scutellum transverse, rounded behind, and finely punctate. Elytra wider than thorax at the base, subparallel; each with 7 linear interrupted discoidal costæ, the sutural entire behind; interstices finely punctured; the sides are not costate but have three series of punctures or granules; there are very few dark scales.

Antennæ very scantily pubescent, basal joint large and gradually thickened, 2nd transverse, 3–8 as long as they are broad; club large, its basal 2 joints transverse and evidently dilated inwardly, the last longer and rotundate. Legs and tarsi with fine yellow hairs.

Mandibles bifid at apex. Labrum emarginate in front, large, finely pubescent.

Larger than *L. brouni*, which measures 4 × 1⅝ lines. The thorax is more transverse, more sinuate behind the middle, with thicker reflexed lateral margins, but it is entirely without the slender yet distinct yellow hairs of that species; its sculpture also is different. The elytral costæ are less numerously interrupted.

Length, 5½–5¾ lines; breadth, 2–2¼ lines.

Te Whakuru, Chatham Islands.

Discovered by Miss S. D. Shand, in whose honour it has been named.

Obs.—Var. *a:* Nearly glabrous; mandibles not bifid, the inner extremity of each broad and obtusely truncate; unique as yet, may prove to be a distinct species; 5½ × 2 lines. Var. *b:* Hind angles of thorax more prominent; 4½ × 1⅝ lines.

Group Lucanidæ.

Lissotes dispar, sp. nov.

Oblong, moderately transversely convex, nitid; fusco-niger, legs piceo-rufous; the lateral and basal margins of the thorax thinly, the sides and apical portion of the elytra more thickly, clothed with short fulvescent setæ; the two hind pairs of tibiæ fringed with slender outstanding setæ.

Mandibles large, strongly curvate, the right one reflexed at the extremity so as to clear the left; on each, near the base, there is a short inner angular projection; just in front of these, and a little lower down, there is a much larger one which touches its fellow during repose; above, near the inner margin of each mandible, from the middle backwards, there is an elongate obtuse elevation.

Head about as large as the thorax, its frontal portion slightly but broadly concave: in front of each eye there is an elongate and rather deep lateral cavity, the margin there is curvate and elevated, behind each eye there is a prominent angular lobe, its sides consequently are rather widely incurved near the middle: it is minutely and distantly punctured, but more distinctly and closely on the hinder part.

Thorax twice as broad as long, widest in front, gradually narrowed backwards till near the base, where the sides are rather more oblique; its apex is widely but not deeply sinuate towards the sides, with rounded angles; base subtruncate, the posterior angles not rounded, nearly rectangular; the disc is minutely and distantly punctured, its sides more distinctly, on some spots indeed quite coarsely.

Scutellum smooth, short and broad, rounded behind.

Elytra only slightly longer than broad, a little contracted towards the base, with obtusely prominent shoulders, which, however, are partly concealed by the thoracic angles; their sculpture is irregular, being rather densely punctured at the base, somewhat rugosely near the apices, and more coarsely at the sides; on each elytron there are 5 or 6 indefinite striæ, and between the middle and side 2 more or less obvious, but not very regular, series of rather coarser punctures than those on the disc.

Anterior tibiæ externally, at the extremity, strongly bidentate, and with 2 or 4 smaller teeth along their sides; the intermediate unidentate medially and obtusely prominent at the outer extremity; the posterior simple, slightly flexuous.

Underside shining, nigrescent, distinctly and closely punctate, and bearing short flavescent setæ; those on the femora and front of prosternum more elongate.

Undoubtedly nearly allied to *L. capito*, Deyrolle, but differing therefrom, judging by its description as recorded by Parry, in sculpture, coloration, and form. The head is not parallel-sided; the thorax is not at all dilated posteriorly, its anterior angles are rather strongly rounded, the basal nearly rectangular, just the reverse of its contour in *L. capito*.

Male.—Length (mandibles inclusive), 12 lines; breadth, 5½ lines.

Te Whakuru, Chatham Islands.

Professor C. Chilton kindly sent me a damaged specimen received by him from Miss S. D. Shand.

Lissotes capito, Deyrolle.

Male.—Large, depressed, deep chestnut, the forehead and legs of a lighter hue, head and thorax very large.

Head very large, with a triangular impression on the forehead, parallel at the sides, anterior angles rounded, shallowly semicircularly emarginate in front, tuberculated laterally behind the eyes; above smooth, without any trace of punctuation; beneath with a rather large triangular impression on each side for the reception of the antennæ in repose, these similar in structure to those of the allied species, the 3 apical joints produced into leaflets. Prothorax much dilated behind, anterior margin nearly straight; sides oblique, sinuated towards the middle, posterior margin semicircularly emarginate; anterior angles slightly, posterior angles strongly rounded; lateral and posterior margins finely ciliated; above smooth, with a slight depression on each side, near the anterior margin; middle of disc and lateral margins slightly punctate. Scutellum short and broad, truncate behind. Elytra subparallel, slightly narrowed anteriorly; shoulders somewhat prominent in front, margined and ciliated at the sides, shining, covered with a sparse punctuation and a very short hispid golden-silky pubescence, each elytron with 4 rather obsolete ridges.

Beneath with the abdomen somewhat thickly punctate, the punctuation sparser on the legs and thorax, with a pubescence similar to that on the upper surface, but shorter and denser; legs clothed with longer hairs, disposed in ciliæ on the intermediate and posterior tibiæ, the anterior tibiæ armed externally in front with 2 large teeth, and behind with 5 or 6 small ones.

Female.—Parry.

Body subdepressed, broad and flat, strongly punctured; anterior angles of the head less produced than in the male, armed with a minute tubercle behind the eyes, which are partially divided by the canthus. Prothorax slightly rounded at the sides, posterior angles scarcely emarginate, with a faint central longitudinal channel and a shallow depression on each side. Elytra, as in the male, slightly costate. Scutellum exceedingly small, transverse. Mandibles short, tridentate at the apex. Tarsi short.

Parry adds that he is indebted to M. Henri Deyrolle for permission to incorporate the description of the male in the present paper, and to the kindness of Mr. F. Pascoe to add a description of the female. A single example of the male exists in the collection of Count Mnizech, and both sexes in that of Mr. Pascoe, their habitat being the Chatham Islands, situate about four hundred miles from the eastern coast of New Zealand.

Obs.—The above descriptions have been copied from the "Transactions of the Entomological Society of London," 1873, p. 339. In that volume figures are given on pl. v. Unfortunately, tracings of these were not asked for, and therefore not sent, so that we in New Zealand remain in doubt regarding the size of the insect and the structure of the mandibles.

Group Cryptorhynchidæ. Gen., Man. N.Z. Coleopt., p. 482.

Aldonus misturatus, sp. nov.

Convex, oblong-oval, moderately nitid; fusco-piceous, antennæ and tarsi piceo-rufous; sparingly clothed with oviform slender scales and erect moderately coarse setæ, all of which are flavescent.

Rostrum slightly shorter than thorax, a little arched, slightly narrower behind the antennal insertion (between the middle and apex) than in front, closely and rugosely but not coarsely punctured near the extremity, irregularly and rather indefinitely tricarinate and punctate behind, abruptly constricted at the base. Thorax very little broader than long, conical, base bisinuate, its obtuse angles resting on the elytra, it is much narrowed towards the rufescent apex, which is sometimes a little constricted; the disc rather coarsely closely and more or less confluently punctured, interstices irregularly rugose, the lateral sculpture granular; it bears a few squamæ, the setæ are most apparent at the sides. Elytra rather wider than thorax at the base; the shoulders prominent, but obtuse in front; they are subparallel as far as the hind thighs, moderately narrowed but not abruptly declivous behind; they are rather strongly punctate-striate, more sharply impressed behind than on the dorsum with rugose and asperate interstices, the sides apparently have coarse serial punctures; the setæ are most conspicuous towards the sides and extremity.

Scape slender, not quite reaching the eye; 2nd joint of funiculus subclavate at apex and obviously longer than the basal one, 3–6 short and nearly equal, 7th larger, about as broad as the oblong-oval, triarticulate, finely pubescent club.

Femora notched and subdentate underneath; tibiæ nearly straight, somewhat compressed, with well-developed terminal hooks, their inner angles spiniform, the setæ more slender than those on the elytra. Tarsi hairy, 1st joint elongate, slender at the base, 2nd oblong yet shorter than the basal one, 3rd short, moderately expanded and bilobed, the terminal about as long as the basal, with simple claws.

Underside shining, rufo-piceous, the sides of the breast with flavescent scales or squamiform setæ, abdomen with fine setæ. Prosternum deeply emarginate in front, rostral canal without sharply defined borders, becoming shallow between the coxæ, and not extending into the mesosternum. Mesosternal process broad, not concave, transversely rugose. Metasternum rather short, punctate, with slender squamæ at the sides. Basal ventral segment as long as the metasternum, broadly medially impressed, rather coarsely but not closely punctured, its apical suture extremely fine, but deep at the sides, distinctly and broadly angulate between the coxæ; 2nd segment shorter, more distantly and finely punctate, transversely impressed behind the middle. The sculpture of the prosternum seems to consist of punctures and minute tubercles, which, however, owing to the thick vestiture, are not easily seen.

Female.—Rostrum as long as thorax, cylindric, rather slender, shining, finely and distantly punctate. Antennæ elongate, slender, and medially inserted.

Length (rostrum exclusive), 3¼–4¾ lines; breadth, 1½–2⅛ lines.

Te Whakuru, Chatham Islands.

Both sexes forwarded by Miss S. D. Shand.

This cannot be Dr. Sharp's A. *chathamensis*, which is clothed above with numerous erect setæ only, whilst the thorax is described as "very rough, with tubercular sculpture."

Aldonus lineifer, sp. nov.

Convex, oblong-oval, only slightly shining, fusco-piceous, antennæ and tarsi pitchy-red; elytra very scantily clad with pale suberect squamæ, and short erect, pale and infuscate setæ.

Rostrum longitudinally rugose and punctate almost to the extremity, and indefinitely carinate along the middle from its base to the point of the antennal insertion. Thorax with moderately coarse punctures and more or less distinct plane intervals, the sides more rugosely and closely punctate but without discernible tubercles or granules, the mesial line smooth; the scales on the sides, in front, are oviform and depressed; there are some similar ones at the base, but on the disc they are slender and indistinct, or altogether absent. Elytra coarsely striate-punctate, quite striate behind, the punctures suboblong, distinctly separated, and encroaching on the interstices in many parts; the suture and interstices finely punctate and rugose. Femora with slender, depressed, elongate scales; the tibiæ with outstanding, moderately fine setæ.

Eyes large, nearly flat, rounded outwardly, truncate inwardly, just free from the thoracic margin, as in the preceding species.

The more scanty vestiture and the sculpture of the thorax render this species distinct.

Male.—Length (rostrum exclusive), 2¾ lines; breadth, 1⅛ line.

Te Whakuru.

Miss S. D. Shand. Unique.

ART. XXXVIII.—*Some Hitherto-unrecorded Plant-habitats* (V).

By L. COCKAYNE, Ph.D.

[*Read before the Philosophical Institute of Canterbury, 3rd November*, 1909.]

THE mosses in the following list were identified by Dr. V. F. Brotherus, of Helsingfors, to whom my warmest thanks are due. I have added in most cases a reference to the description of the species in Hooker's "Handbook of the New Zealand Flora." No list of Mount Peel or of Upper Rakaia plants having been published, species comparatively common receive mention. The Mount Peel vegetation was studied only on the slopes facing the Canterbury Plain. By the "Upper Rakaia" is meant the country near the main sources of that river, especially the river-bed on the southern side and the slopes of that part of the Arrowsmith Range known as Mount Murray, at a distance of about one mile from Mein's Knob, a *roche moutonnée* just opposite the terminal face of the Ramsay Glacier.

I must express my great obligations to various members of this Institute and others who have been so good as to collect specimens for me,* and especially to Mr. W. Willcox, of the Tourist Department, who is most assiduously collecting the alpine plants in the Otago lakes district, with the object of making a garden of New Zealand mountain plants in the Queenstown Park. Such a work is of national importance, and the collection will be not only a special attraction to visitors, but one of the greatest scientific value.

For sake of easy reference, the species noted in this paper are arranged in alphabetical order, and not according to the sequence of families.

MUSCI.

Bartramia Halleriana, Hedw.—Handb., p. 446.

South Island: Canterbury—Base of Craigieburn Mountains, in subalpine beech forest, at altitude of about 660 m. L. C.

Brachythecium rutabulum (L.).—*Hypnum;* Handb., p. 478.

North Island: Auckland—Central volcanic plateau, growing on floor of subalpine beech forest, at altitude of 1,120 m. L. C.

Bryum leptothecium, Tayl.—Handb., p. 439. (Referred to *Rhodobryum* in "Index Bryologicus."†)

(1) North Island: North Auckland—Waipoua kauri forest, growing on rotting logs; L. C. (2) South Island: Canterbury—Base of Craigieburn Mountains, in subalpine beech forest, at altitude of about 650 m.; L. C.

Dicranoloma leucolomoides (C. Muell.).—*Dicranum dicarpon,* Hornsch; Handb., p. 411.

North Island: Central volcanic plateau, forming extensive mats on floor of subalpine beech forest, at altitude of about 1,120 m. L. C.

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* Since reading this paper I have received a number of interesting specimens and notes on distribution from various correspondents, especially Mr. D. L. Poppelwell, of Gore, to whom I am much indebted, but an account of these must necessarily be held over for a future paper.

† Paris, E. G.: "Index Bryologicus," 1894–98.

Dicranoloma robusta (Hook. f. & Wils.).—*Dicranum ;* Handb.

South Island: Canterbury—Base of Craigieburn Mountains, growing on floor of subalpine beech forest, at altitude of 650 m. and upwards. L. C.

Dicranoloma Menziesii (Tayl.).—*Dicranum ;* Handb., p. 412.

North Island: North Auckland—Waipoua kauri forest, forming considerable patches on floor. L. C.

Dicranoweissia chrysea, Beckett.

South Island: Canterbury—Craigieburn Mountains. L. C.

Distichium capillaceum, Hook. f.—Handb., p. 422.

South Island: Canterbury—Terrace of River Porter, growing in montane steppe. L. C.

Echinodium hispidum (Hook. f. & Wils.), Jaeg.—*Hypnum;* Handb., p. 473. (In Index Bryolog. referred to *Sciaromium.*)

North Island: North Auckland—Waipoua kauri forest, growing on stones of stream in shady gully. L. C.

Hymenodon piliferus, Hook. f. & Wils.—Handb., p. 486.

North Island: North Auckland—Waipoua kauri forest, forming extensive pale-green colonies on trunk of *Cyathea dealbata.*

Hypnum uncinatum, Hedw.—Handb., p. 472.

South Island: Canterbury—Base of Craigieburn Mountains, growing in subalpine beech forest on gravelly ground. L. C.

Leptostomum gracile, R. Br.—Handb., p. 435.

North Island: Auckland—Volcanic plateau; epiphytic on trunk of *Nothofagus cliffortioides.* forming green masses. subalpine beech forest, at about altitude of 1,120 m. L. C.

Leptostomum macrocarpum (Hedw.), R. Br.—Handb., p. 436.

(1) Kapiti Island, Cook Strait: Forming dense cushion on shaded rock; L. C. (2) South Island: Canterbury—Base of Craigieburn Mountains, in subalpine beech forest; epiphytic on trunk of *Nothofagus cliffortioides,* forming dense peaty cushions; L. C.

Leucobryum candidum (Brid.), Jaeg.—Handb., p. 409.

North Island: North Auckland—Waipoua kauri forest, growing on bases of tree-trunks. L. C.

Polytrichadelphus magellanicus (L.), Mitt.—*Polytrichum ;* Handb., p. 454.

South Island: Canterbury—Broken River valley, growing in montane *Sphagnum* bog, at about altitude of 600 m. L. C.

Sciadocladus Menziesii (Hook.), Jaeg.—*Isothecium ;* Handb., p. 465. (Referred in Index Bryolog. to *Hypnodendron.*)

North Island: North Auckland—Waipoua kauri forest, forming colonies on the floor. L. C.

PTERIDOPHYTA.

Alsophila Colensoi, Hook. f.

South Island: Canterbury—(1) Mount Murray, head of Rakaia; M. C. Gudex! (2) Mount Peel, in forest; L. C. This habitat has already been cited by Potts in "Out in the Open," p. 244, but it seems well to record it again notwithstanding.

Asplenium flabellifolium, Cav.

South Island: Canterbury—Totara forest, Upper Rakaia, at altitude of about 800 m. L. C.

The above altitude is somewhat in advance of that given in the Manual. p. 988.

Cyathea medullaris (Forst. f.), Sw.

In my report on Stewart Island, p. 45, the habitat is accidentally given as Half-moon Bay instead of Horse-shoe Bay, though it is correctly marked on the map.

Histiopteris incisa (Thunb.), J. Sm.

South Island: Canterbury—Head of Rakaia, on Mount Murray, at about altitude of 1,000 m. M. C. Gudex!

Polypodium Billardieri (Willd.), C. Chr.; syn., *P. australe*, Mett.

This is stated in my report on Stewart Island, p. 47, as "making extensive colonies on the forest-floor," which is incorrect, the species occurring only on trees or rocks. The statement was really intended to refer to *P. diversifolium*, Willd., which is universally known by New Zealand botanists as *P. Billardieri*.

Polystichum cystotegia (Hook.), Armstg.

South Island: Canterbury—Source of River Rakaia, amongst stones. M. C. Gudex!

SPERMOPHYTA.

Aciphylla brevistyle (Hook. f.).

South Island: Otago—Hector Mountains; subalpine. W. Willcox!

Aciphylla Dieffenbachii (F. Muell.), T. Kirk.

Chatham Islands: Chatham Island, on cliff at Te Tuku. A. A. Dorrien Smith!

This plant was thought to be possibly extinct on Chatham Island, but Captain Dorrien Smith reports that it is plentiful in the above locality. The truth is that most likely it is quite eaten out on the ordinary ground, but that it occurs in various places on precipitous cliffs in the west and south. Mr. H. H. Travers states that it occurs in a similar situation on Pitt Island.

Aciphylla Dobsoni, Hook. f.

South Island: Canterbury—Summit of the Liebig Range. Johannes C. Andersen!

Aciphylla pilifera (Hook. f.), var. pinnatifidum, T. Kirk.

South Island: Canterbury—Mount Murray, head of River Rakaia, on rocky ground, at about 1,400 m. altitude. L. C.

Aira Caryophyllea, L. (introduced).

Chatham Island. R. B. Oliver!

Ammophila arenaria, Lk. (introduced).

Chatham Island; on dunes. R. B. Oliver and L. C.!

Anthoxanthum odoratum, L. (introduced).

Chatham Island. R. B. Oliver!

Archeria Traversii, Hook. f.

South Island: Canterbury—(1) Upper Rakaia, on river-bed near its source, growing with other shrubs at altitude of about 950 m; L. C. (I did not note any plants of this species in the subalpine scrub proper, though doubtless it must be there.) (2) Common in subalpine scrub at sources of River Poulter; L. C.

Astelia Petriei, Cockayne.

South Island: Canterbury—(1) Mount Peel, on subalpine meadow, L. C.; (2) Mount Murray, near source of River Rakaia, at margin of subalpine scrub, L. C.: Otago—Lake Harris Saddle; W. Willcox!

Brachycome Thomsoni, T. Kirk.

South Island: Canterbury — Port Hills, beneath summit cliffs, on shaded side. L. C.

Less robust and glandular than the Stewart Island plant.

Bromus hordeaceus, L. (introduced).

Chatham Island. R. B. Oliver!

Bromus unioloides, H. B. K. (introduced).

Chatham Island. R. B. Oliver!

Cardamine depressa, Hook. f.

South Island: Canterbury — Mount Catherine, near Lake Heron, on rock, at altitude of 1,200 m. L. C.

Carex virgata, Sol.

Chatham Island: In lowland swamp. R. B. Oliver!

Carmichaelia Enysii, T. Kirk.

South Island: Canterbury — Ashburton River, near Hakatere, growing on old stony bed. L. C.

Cheeseman cites "Ashburton Mountains, *Potts*," but had not seen an authentic specimen from that locality. (Manual, p. 11.)

Celmisia discolor, Hook. f.

South Island: Canterbury—Mount Peel. L. C.

This is the form with spathulate leaves, not the linear-leaved variety common on certain of the "dry" mountains of Canterbury.

Celmisia petiolata, Hook. f.

South Island: Otago—Hector Mountains; subalpine. W. Willcox!

Celmisia prorepens, Petrie.

South Island: Otago—Hector Mountains; alpine. W. Willcox!

The Old Man Range is the furthest southern limit recorded hitherto.

Celmisia pseudo-Lyallii, Cockayne, comb. nov. *C. Lyallii*, Hook. f., var. *pseudo-Lyallii*, Cheesem., in Man. N.Z. Flora, p. 312, 1906.

South Island: Canterbury—Mount Peel; subalpine. Mrs. F. Waymouth! L. C.

I have always considered this a valid species. Mr. T. Kirk referred my specimens to *C. spectabilis*, Hook. f. The leaf is altogether different from that of *C. Lyallii*, which is extremely stiff and coriaceous, tapers to an almost pungent point, is grooved on both surfaces, has no evident midrib, and is thinly tomentose on the ridges of the under-surface only. *C. pseudo-Lyallii* has a much less stiff leaf, which is tapering and acute, but not drawn out to a fine pungent point. There are no regular grooves and ridges, but the upper surface is plaited and dark- not yellowish-green; the midrib is keeled on the under-surface, which latter is thickly tomentose with dense silky tomentum. So far as I know, *C. pseudo-Lyallii* is confined to the drier mountains of Canterbury. Probably, too, it is one of the species which have been confused with *C. monroi*, Hook. f.

Celmisia sessiliflora, Hook. f.

South Island: Westland—Neighbourhood of the Franz Josef Glacier. J. M. Bell!

Clematis australis, T. Kirk.

South Island: Canterbury — Upper Rakaia, in subalpine scrub or trailing amongst grass on stony *débris*, at an altitude of 950 m. to 1,000 m. or thereabouts. L. C.

Colobanthus acicularis, Hook. f.

South Island: Canterbury—(1) On rocks, Mount Peel; L. C. (2) On rocks, Mount Catherine, near Lake Heron, at altitude of 1,200 m.; L. C.

Colobanthus brevisepalus, T. Kirk.

South Island: Canterbury — On tussock steppe near Lake Heron, chiefly on dry exposed face of river terrace. L. C.

Coprosma rugosa, Cheesem.

South Island: Canterbury — In subalpine scrub on Mount Murray, Upper Rakaia. L. C.

Coprosma Petriei, Cheesem.

South Island: Canterbury—On tussock steppe and stony ground near Lake Heron. L. C.

Coprosma serrulata, Hook. f.

South Island: Canterbury—Mount Peel, on rocky buttresses. Mrs. F. Waymouth! L. C.

Corallospartium crassicaule (Hook. f.), J. B. Armstg.

South Island: Otago—Hector Mountains. W. Willcox!
The furthest southern record in the Manual is the Dunstan Mountains.

Dacrydium Bidwillii, Hook. f.

South Island: Canterbury—Growing on *Sphagnum* cushions in bog and also at margin of tarn on old moraine near mouth of Lake Stream, Upper Rakaia. L. C.

Dracophyllum Kirkii, Berggr.

South Island: Canterbury — Mount Murray, Upper Rakaia, on rocks at about 1,450 m. altitude. L. C.

Dracophyllum rosmarinifolium, Hook. f.

South Island: Canterbury—Neighbourhood of Cameron Glacier; R. Speight! Westland—Summit of Mount Greenland, in boggy ground, subalpine: L. C.

Eleocharis neo-zealandica, C. B. Clarke.

A plant from the dunes of western Wellington was incorrectly referred to this species by me in Trans. N.Z. Inst., vol. xli, p. 399, and in my "Report on Sand Dunes," p. 25.

Epilobium pycnostachyum, Haussk.

South Island: Canterbury—On shingle-slip at 1,000 m. and upwards on Mount Murray, Upper Rakaia. L. C.

Gaultheria perplexa, T. Kirk.

South Island: Canterbury—Straggling amongst shrubs on river-bed, Upper Rakaia. L. C.

Helichrysum grandiceps, Hook. f.

South Island: Westland—Close to Franz Josef Glacier, on ice-worn rock at about 300 m. altitude. L. C.

Helichrysum Selago, Benth. & Hook. f.

South Island: Canterbury — Mount Catherine, on face of rock, at 1,200 m. altitude. L. C.

Hordeum murinum, L. (introduced).

Chatham Island. R. B. Oliver!

Libocedrus Bidwillii, Hook. f.

South Island: Canterbury — Upper Rakaia, in subalpine totara forest. L. C.

Metrosideros lucida, Menzies.

South Island: Canterbury — Mount Peel, in montane forest; the principal tree. L. C.

Microlæna Colensoi (Hook. f.). — Petrie in lit. comb. nov. *Ehrharta Colensoi*, Hook. f., in Fl. Nov. Zel., i, 288, t. 65A.

South Island: Canterbury—Mount Peel, on subalpine rocks. L. C.

Muehlenbeckia ephedrioides, Hook. f.

South Island: Canterbury — Neighbourhood of Lake Heron, on old stony river-bed. L. C.

Myosotis Forsteri, Lehm.

South Island: Canterbury — Upper Rakaia, on river-bed, near running stream. L. C.

Nothofagus cliffortioides (Hook. f.), Œrst.

South Island: Canterbury—From Ashburton Gorge to near mouth of Lake Stream, occasionally in sheltered gullies, but not extending further up the Rakaia. L. C.

Nothofagus fusca (Hook. f.), Œrst.

Found only at a considerably higher altitude to west of Ruapehu than is given in my "Report of Tongariro National Park," p. 19.

Nothopanax parvum (T. Kirk), Cockayne.

South Island: Canterbury—Upper Rakaia, amongst shrubs on side of river-bed; not common. L. C.

Nothopanax simplex (Forst. f.), Seem.

South Island: Canterbury—Upper Rakaia, in subalpine totara forest: not very abundant. L. C.

Oreobolus pectinatus, Hook. f.

South Island: Canterbury—Mount Peel, in wet ground. L. C.

Ourisia macrocarpa, Hook. f.

South Island: Canterbury—Source of Rakaia. M. C. Gudex!

Ourisia sessiliflora, Hook. f.

South Island: Westland—Neighbourhood of Franz Josef glacier. J. M. Bell!

Pentachondra pumila, R. Br.

South Island: Canterbury—Mount Peel. L. C.

Pernettya nana, Col.

South Island: Canterbury—Near Lake Heron, in rather wet ground. L. C.

Pimelia Lyallii, Hook. f.

South Island: Canterbury—Mount Peel. L. C.

Pimelea Traversii, Hook. f.

South Island: Canterbury — Mount Catherine, on face of rock, at 1,200 m. altitude. L. C.

Plantago triandra, Berggr.

South Island: Canterbury—Neighbourhood of Lake Heron, in *Sphagnum* bog; L. C. Westland—Otira Valley, near railway-station; L. C.

I am by no means sure that the above species is distinct from *P. uniflora*, Hook. f.

Poa anceps, Forst. f., var.

South Island: Canterbury — Upper Rakaia, on shingle-slip and river-bed, ascending to probably 1,500 m. or more. L. C.

Poa Lindsayi, Hook. f.

South Island: Canterbury — Neighbourhood of Lake Heron, on montane tussock steppe. L. C.

Poa novæ-zealandiæ, Hack.

South Island: Canterbury—Upper Rakaia. L. C.

A specimen was noted growing as an epiphyte in the subalpine totara forest, but the ordinary station was shaded rocks.

Pseudopanax crassifolium (Sol.), C. Koch.

South Island: Canterbury — Upper Rakaia, in subalpine totara forest, at more than 900 m. altitude. L. C.

The altitudinal limit as given in the Manual is 610 m.

Pterostylis mutica, R. Br.

South Island: Canterbury — Neighbourhood of Lake Heron, on montane tussock steppe, local. L. C.

Ranunculus acaulis, Banks & Sol.

South Island: Canterbury—Sand-plain near Sumner Estuary. L. C.

Ranunculus Godleyanus, Hook. f.

South Island: Canterbury—Upper Rakaia; but saw only one plant, which was growing on the river-bed in a shallow stream. M. C. Gudex! Probably the species is quite common on the north side (shaded side) of the river.

Ranunculus Monroi, Hook. f., var. dentatus, T. Kirk.

South Island: Canterbury—(1) Mount Peel, on rocks at about 1,200 m. altitude; Mrs. F. Waymouth! L. C. (2) Rocks on Mount Catherine, near Lake Heron, at about same altitude as above; L. C.

Ranunculus tenuicaulis, Cheesem.

South Island: Otago—Ben Lomond. W. Willcox!

Ranunculus Traversii, Hook. f.

Mr. Willcox collected a plant on Mount Earnslaw with cream-coloured flowers which may belong to the above.

For some remarks *re* this "species," see my first paper of this series (Trans. N.Z. Inst., vol. xxxvii, p. 364).

Raoulia Buchanani, T. Kirk ?

South Island: Otago—Vicinity of Lake Harris Saddle. W. Willcox!

Only recorded previously from Mount Alta, one specimen alone having been collected.

Raoulia Haastii, Hook. f.

South Island: Canterbury — Rakaia river-bed, in subalpine and montane zone, especially in region of average western rainfall; very abundant, forming large green cushions. L. C.

Rubus schmidelioides, A. Cunn., var. coloratus, T. Kirk.

South Island: Canterbury — Upper Rakaia, in subalpine totara forest. L. C.

The above seems to me much more closely related to *R. subpauperatus*, Cockayne, than to *R. schmidelioides*, A. Cunn.

Senecio cassinioides, Hook. f.

South Island: Canterbury — Upper Rakaia, in subalpine scrub, but not very abundant. L. C.

Senecio elæagnifolius, Hook. f.

South Island: Canterbury — Mount Peel, in montane forest, and probably in subalpine scrub. L. C.

Senecio lautus, Forst. f., var. montanus, Cheesem.

South Island: Canterbury — Upper Rakaia, on subalpine shingle-slip on Mount Murray. L. C.

Sisyrinchium chilense, Hook. (introduced).

South Island : Otago—Neighbourhood of Queenstown. W. Willcox !

Sophora microphylla, Ait.

South Island : Canterbury—Upper Rakaia, in totara forest, but hardly ascending to the subalpine zone. L. C.

The trees are of unusual size, many being over 50 ft. tall, and more than 1 ft. in diameter.

Stackhousia minima, Hook. f.

South Island : Canterbury—Neighbourhood of Lake Heron, on montane steppe. L. C.

Suttonia nummularia, Hook. f.

South Island : Canterbury—Mount Peel. L. C.

Triodia exigua, T. Kirk.

South Island : Canterbury—Neighbourhood of Lake Heron, on montane steppe. L. C.

Trisetum Youngii, Hook. f.

South Island : Canterbury—Upper Rakaia, on river-bed steppe. L. C.

Tupeia antarctica, Hook. f.

South Island : Canterbury—Upper Rakaia : very common on *Gaya Lyallii*, in the subalpine totara forest. L. C.

Veronica epacridea, Hook. f.

South Island : Canterbury—Near Cameron Glacier ; R. Speight ! Otago—Garvie Mountains ; D. L. Poppelwell !

Veronica leiophylla, Cheesem.

South Island : Canterbury—Mount Somers, on limestone. L. C.

Veronica lycopodioides, Hook. f.

South Island : Canterbury—Mount Peel. L. C.

Veronica macrantha, Hook. f.

South Island : Canterbury—Upper Rakaia, at about 1,450 m. altitude on Mount Murray. L. C.

Veronica Petriei (Buch.), T. Kirk.

South Island : Otago—Lake Harris Saddle. W. Willcox !

Veronica pinguifolia, Hook. f.

South Island : Canterbury—Mount Peel. L. C.

Veronica subalpina, Cockayne.

South Island : Canterbury—Upper Rakaia ; the chief *Veronica* of the subalpine scrub ; L. C. Westland—Close to Franz Josef Glacier, at altitude of less than 300 m. ; L. C.

ART. XXXIX.—*List of Lichenes and Bryophytes collected in Stewart Island during the Botanical Survey of* 1908.

By L. COCKAYNE, Ph.D.

[*Read before the Philosophical Institute of Canterbury, 6th October,* 1909.]

THE following were, with a few exceptions, collected in October, 1908, during my investigation of Stewart Island botany for the Department of Lands and Survey. The identifications were made by Dr. G. Lindau (Royal Botanical Museum of Berlin), Dr. V. F. Brotherus (Helsingfors), and Mr. F. Stephani (Leipzig), to which eminent specialists I am deeply grateful. Unfortunately, the identifications arrived too late for insertion in my report to the Department.

For the sake of easy reference, the species are arranged in alphabetical order, and their position in Hooker's "Handbook of the New Zealand Flora" is also cited.

Mr. J. W. Murdoch rendered most valuable assistance in collecting, and to him my warmest thanks are due.

Stewart Island is extremely rich in bryophytes and lichens, and this list must be looked upon as merely a small contribution towards the knowledge of these interesting plants.

LICHENES. (Identified by Dr. G. Lindau.)

Cladonia aggregata (Sw.), Ach.—Handb., p. 561.
On open peaty ground, common.

Cladonia fimbriata (L.), Fr.—Handb., p. 560.
On open peaty ground, common.

Cladonia retipora (Lab.), Fr.—Handb., p. 561.
Heath of ancient dunes, common.

Nephroma schizocarpum, Nyl.—Handb., p. 565.
Forest, on bark of trees ?

Pannaria mariana, Müll. Arg. var.
Forest, on bark of trees.

Parmeliella triptophylla (Ach.), Müll. Arg.—*Pannaria;* Handb., p. 576.

Sphærophorus australis, Laur.
Forest, on peaty ground.

Sphærophorus tener, Laur.—*Sphærophoron tenerum*, Laur.; Handb., p. 559.
Forest and open ground.

Stereocaulon ramulosum, Ach.—Handb., p. 562.
Rocky and open ground.

Sticta filicina (Ach.), Nyl.—Handb., p. 568.
Forest, common on trees, logs, &c.

Sticta foveolata (Del.). Nyl. —Handb., p. 569. included with *S. fossulata*, Duf.

Forest, on branches of shrubs.

Sticta fossulata, Duf.—Handb., p. 569.

Forest. abundant on trunks of trees.

Sticta variabilis, Ach.—Handb., p. 568.

Forest. common on trunks of trees and on floor.

Thysanotherium hyalinum (Tayl.), Nyl.

Xanthoria parietina (L.), Th. Fr.—*Parmelia;* Handb., p. 573.

Rocks.

HEPATICÆ. (Identified by Mr. F. Stephani.)

Aneura eriocaula (Hook.), Mitt.—Handb., p. 544.

Forest. common on floor of moist gullies.

Aneura equitexta, Steph.

Forest, on moist rotten logs, &c.

Aneura marginata, Col.

Forest, on moist rotten logs, &c.

Anthoceros giganteus, Lehm. & Lind.—Handb.. p. 548.

Forest, on floor.

Chandonanthus squarrosus (Hook.), Mitt.—*Jungermannia;* Handb., p. 503. (So identified by Brotherus.)

? Forest. on floor.

Chiloscyphus bidentatus, Steph.

? Forest, on logs.

Chiloscyphus decipiens, Gotts.—Handb., p. 516.

Forest, on floor and logs.

Chiloscyphus echinellus, Lind. & Gottsch.—Handb., p. 517.

Moist bank, in company with *Marchantia cephaloscypha*, Steph., and *Gunnera albocarpa*, Cockayne.

Cuspidatula monodon (Tayl.), Steph. —*Jungermannia;* Handb., p. 502.

Peaty ground, in open.

Frullania falciloba, Tayl.--Handb., p. 536.

Forest, ? on logs.

Hymenophytum Phyllanthus (Hook.). Steph. — *Podomitrium;* Handb., p. 540.

Forest, very abundant on trunks of tree-ferns and moist ground of gullies.

Isotachis intortifolia, Hook. f. & Tayl.—Handb., p. 526.

Open peaty ground.

Lepidozia capilligera, Lehm. & Lind.—Handb., p. 521.
Open peaty ground.

Lepidozia patentissima, Tayl.—Handb., p. 522.
Forest, on floor. growing with *Nertera depressa*, Banks & Sol.

Lepidozia Taylori (Gotts.), Steph.
Forest. on trees and logs.

Marchantia cephaloscypha, Steph.
Open ground, on moist banks.

Mastigobryum Mooreanum, Steph.
Forest. on floor, forming mats.

Monoclea Forsteri, Hook.
Forest, on stones of shallow streams and wet banks.

Plagiochila annotina (Menz.). Lind.—Handb., p. 507.
Forest. on floor, forming close masses.

Plagiochila conjugata (Hook.), Dum.—Handb., p. 504.
Forest, on tree-trunks, forming close covering.

Plagiochila deltoidea, Lindb.—Handb., p. 506.
Forest, on tree-trunks, forming close masses.

Plagiochila gigantea (Hook.), Lindb.—Handb., p. 505.
Forest, on floor, forming tall masses and cushions.

Plagiochila Howeana, Steph.
Forest, on floor, logs, and trees.

Plagiochila inæqualis, Steph.
Forest. on floor.

Plagiochila Lyallii, Mitt.—Handb., p. 507.
Forest, on floor and logs.

Plagiochila ramossissima (Hook.), Lindb.—Handb., p. 505.
Forest, on floor, ? forming cushions.

Plagiochila strombifolia, Tayl.
Forest. on trees and floor; perhaps a cushion-former.

Schistochila ciliata (Mitt.), Steph.—*Gottschea;* Handb., p. 513.
Forest, on moist floor.

Schistochila nobilis (Hook.), Dum.—*Gottschea;* Handb., p. 513.
Forest, bottoms of wet gullies.

Schistochila marginata (Col.), Steph.
Forest, on damp floor.

Schistochila unguicularis (Tayl.), Steph.—*Gottschea;* Handb., p. 513.
Forest, moist gullies and stems of tree-ferns.

Symphiogyna crassicosta, Steph.
Forest, in company with *Monoclea Forsteri*, Hook., in wet situations.

Trichocolea lanata, Nees.—Handb., p. 527.
Forest, on floor, in damp situations.

Trichocolea tomentilla, Nees.—Handb., p. 527.
Forest, on damp floor, forming extensive patches.

Tylimanthus saccatus (Hook.), Mitt.—*Gymnanthe;* Handb., p. 520.
Forest, on floor and logs.

MUSCI. (Identified by Dr. V. F. Brotherus.)

Barbula calycina, Schw.
Sandy ground probably near shore of Paterson Inlet.

Campylopus bicolor, Hornsh.—Handb., p. 415.
Bogs, Port Pegasus.

Campylopus introflexus, Hedw.—Handb., p. 414.
Open ground, on peaty soil; bogs, Mount Anglem, in subalpine zone.

Campylopus torquatus (Hook. f. & Wils.), Mitt.—Handb., p. 414.
Open ground, on clayey soil.

Dicranoloma Billardieri, Schw.—*Dicranum;* Handb., p. 412.
Forest, on floor, building great cushions in moist places.

Dicranoloma Menziesii (Tayl.).—*Dicranum;* Handb., p. 412.
Forest, on floor, logs, and bases of trees.

Dicranoloma platycaulon, C. Muell.
Forest, on logs, &c.

Dicranoloma setosa (Hook. f. & Wils.).—*Dicranum:* Handb., p. 412.
Bogs and open ground, Port Pegasus.

Dicranoloma subpungens (Hook. f. & Wils.).
Subalpine boggy meadow, Mount Anglem.

Distichophyllum rotundifolium, Hook. f. & Wils.
Forest, on rotten wood.

Ditrichum affine.
Open ground, on clayey soil.

Eriopus cristatus.
Forest, on floor and logs.

Hymenodon piliferus, Hook. f. & Wils.—Handb., p. 486.
Forest, on trunks of tree-ferns.

Hypopterygium novæ-seelandiæ, C. Müll.—Handb., p. 487.
Forest, on floor, abundant.

Lembophyllum cochlearifolium, Schw.—*Hypnum;* Handb., p. 480.
Forest, on trees and logs, common.

Lembophyllum vagum (Hornsch.).—*Hypnum;* Handb., p. 481.
Forest, on ground and logs.

Leptostomum macrocarpum, R. Br.—Handb., p. 436.
Forest, on tree-trunks.

Leucobryum candidum (Hornsch.).—Handb., p. 409.
Forest, bases of trunks, common.

Leucobryum brachyphyllum, Hamp.—Handb., p. 409, included with *L. candidum.*
Forest, bases of trunks.

Lopidium pallens, Hook. f. & Wils.—*Hypopterygium Struthiopteris*, Brid.: Handb., p. 489.
Forest, on trees and logs.

Mniodendron comatum (C. Müll.).—*Isothecium;* Handb., p. 467.
Forest, on floor and logs, common.

Mniodendron comosum (Labill).—*Isothecium;* Handb., p. 466.
Forest, on floor and logs, common.

Pohlia nutans, Schreb.
Open ground, on peaty soil.

Polytrichum juniperinum, Willd.—Handb., p. 455.
Open ground, on peaty soil.

Rhacopilum strumiferum (C. Müll.).
Forest, on logs and ? trunks.

Rhapidostegium cerviculatum (Hook. f. & Wils.).—*Hypnum;* Handb., p. 473.
Forest, on trunks and logs.

Rhapidostegium leptorrhynchium, Schur.—*Hypnum;* Handb., p. 475.
Forest, on trunks.

Rhapidostegium leucocythos (C. Müll.).—Handb., p. 475, as syn. for *Hypnum leptorrhynchum*, Brid.
Forest, on trunks and logs.

Rhizogonium distichum, Brid.—Handb., p. 484.
Forest, on tree-fern stems.

Rhizogonium novæ-hollandiæ, Brid.—Handb., p. 484.
Forest, on tree-fern stems.

Sciadocladus Menziesii (Hook. f. & Wils.).—*Isothecium;* Handb., p. 465.
Forest, on floor, common.

Stereodon chrysogaster (C. Müll.), Mitt.—*Hypnum;* Handb., p. 475.
Forest, on trunks.

Tayloria octoblepharis.
In open, on peaty soil.

Thuidium furfurosum (Hook. f. & Wils.).
Forest, on trees and logs.

ART. XL.—On a Non-flowering New Zealand Species of Rubus.

By L. COCKAYNE, Ph.D.

[*Read before the Philosophical Institute of Canterbury, 6th October, 1909.*]

IN the summer of 1898 the late Mr. S. D. Barker, of Christchurch, discovered one plant of a species of *Rubus* growing on the floor of the taxad forest at Inchbonny, near Lake Brunner, Westland. He brought away some rooted pieces, which, planted in his garden, soon became well established. One piece also he very kindly gave me. This latter I managed to grow, and was soon able to distribute plants amongst certain of my friends; while one example was planted, in 1903, in the rock-garden attached to Dr. Chilton's laboratory, Canterbury College, where it is now growing luxuriantly.

The species appeared to me amply distinct from any other New Zealand form of the genus, so I gave it the provisional name of *Rubus Barkeri*, intending to describe it as soon as it should flower. For this event I have waited year by year, but up to the present time no blooms have appeared, although the original specimens were evidently taken from an adult plant. Thinking that perhaps the shady station under which it was growing at Canterbury College might affect its blooming-capability, I cultivated several examples under different conditions of dryness and exposure, but without changing its habit; also, a shoot was tied to a support, so as to imitate the liane form, but this likewise did not flower. As it is now nearly twelve years since the plant was brought into cultivation, I have come to the conclusion that it may never flower, and that the parent will be also flowerless.

Rubus Barkeri is non-climbing, and closely related to *R. parvus*, Buch., so far as habit and leaf-form go, the latter species also being abundant in the same neighbourhood. Possibly the species under consideration is a recent break from *R. parvus*, the new characters having originated by mutation. Equally possible is the chance of its being a hybrid between one or other of the species of *Rubus*, especially *R. australis* and *R. parvus*, though this view is somewhat discounted by the non-climbing habit. Both suppositions are supported by the fact of the one plant alone having been found, while its rapid vegetative increase favours the belief in its incapacity to bloom.

Whether the non-flowering depends upon the environments hitherto provided being unsuitable, as is the case with certain non-flowering plants in Europe* and elsewhere, or whether the species is actually unable to bloom, the future alone will determine. In any case, the behaviour of the plant up to the present is of interest, and seems worthy of record. The rooted pieces, as stated above, were taken from an adult plant, and should have bloomed readily and quickly had the parent been of a normal flowering habit.

Other species of *Rubus* indigenous to New Zealand behave abnormally in their blooming. *R. schmidelioides*, as I have shown,† has a juvenile form distinct from the adult; the former, though attaining great dimensions, never flowering, and being chiefly a plant of the forest-floor; but the latter, as a liane, having gained a more advantageous position with regard to the illumination, flowers abundantly. Here, then, the hygrophytic form is the non-flowering, thus resembling *R. Barkeri.* In the case of *Rubus cissoides*, var. *pauperatus*, the opposite occurs. This plant, when growing as a shrub in the open, its leaves reduced to midribs, rarely, or probably never, flowers; but where sheltered, or when a liane in the forest, its leafy shoots blossom abundantly. That the leafy and leafless forms of this species are one and the same my culture experiments have fully proved.[*] *Rubus subpauperatus*, which has an identical growth-form with the xerophytic form of the last-named species, and grows in its company, flowers more or less freely. From the above examples it may be seen that there is no general rule as to the causes favouring flowering, or the contrary, in the New Zealand *Rubi.*

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* See Kerner, "Pflanzenleben" (English translation), vol. ii. pp. 453–63.

† "Report on a Botanical Survey of the Waipoua Kauri Forest," p. 28, 1908.

Rubus Barkeri, sp. nov.

Fruticulus prostratus ramosissimus, ramis inermibus v. paulum aculeatis gracilibus elongatis radicantibus, foliis 3- raro 1-foliatis circ. 14 cm. longis, foliolis lanceolatis circ. 3–8 cm. longis basi truncatis v. inaequalibus serratis membranaceis, petiolis costisque parce aculeatis pilosisque.

South Island: Westland — near Lake Brunner, on the forest-floor: S. D. Barker!

The species is closely allied to *Rubus parvus*, Buch., but differs in the trifoliate leaves with lanceolate leaflets and not simple linear leaves, serrate rather than dentate leaf-margins, non-blooming habit, and greater size in all its parts.

The terminal leaflet is the largest, measuring about 7·6 cm. by 2·8 cm., the size of the smaller lateral ones being about 6 cm. by 2·1 cm. The leaves are pale green on the undersurface, but above vary much in colour according to the season of the year and the exposure to light. This is most marked in autumn and winter, when the colour is bronzy with a lustrous sheen, or various shades of purple. Even in summer the coloration of the upper surface is striking. Where the light is dim the leaves remain green.

This beautiful leaf-coloration, the habit of the plant, and the ease with which it can be cultivated, make Barker's *Rubus* a quite important decorative plant, especially for rock-gardens, where in the future it will doubtless become a universal favourite.

Rubus parvus exhibits a similar coloration, but to a much lesser degree.

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[*] Trans. N.Z. Inst., vol. xxxiii, p. 293, 1900.

ART. XLI.—*Some Theorems relating to Sub-Polar Triangles.*

By EVELYN G. HOGG, M.A., Christ's College, Christchurch.

[*Read before the Philosophical Institute of Canterbury, 1st December, 1909.*]

§1. LET the straight lines joining the vertices of the triangle ABC to the points O_1, O_2 meet the opposite sides BC, CA, AB, in D_1D_2, E_1E_2, F_1F_2, respectively; then the triangles $D_1E_1F_1$, $D_2E_2F_2$ are termed sub-polar triangles, the points O_1, O_2 being their respective poles.

The vertices of any two sub-polar triangles lie on a conic, for, taking the co-ordinates of the points O_1, O_2 to be $(\alpha_1 \beta_1 \gamma_1)$, $(\alpha_2 \beta_2 \gamma_2)$ respectively, it may be at once verified that the conic

$$\frac{\alpha^2}{\alpha_1 \alpha_2} + \frac{\beta^2}{\beta_1 \beta_2} + \frac{\gamma^2}{\gamma_1 \gamma_2} - \beta\gamma\left(\frac{1}{\beta_1 \gamma_2} + \frac{1}{\beta_2 \gamma_1}\right) - \gamma\alpha\left(\frac{1}{\gamma_1 \alpha_2} + \frac{1}{\gamma_2 \alpha_1}\right)$$
$$- \alpha\beta\left(\frac{1}{\alpha_1 \beta_2} + \frac{1}{\alpha_2 \beta_1}\right) = o \quad . \quad . \quad . \quad . \quad . \quad . \quad (i)$$

passes through the vertices of $D_1E_1F_1$ and $D_2E_2F_2$.

If the points O_1, O_2 be regarded as being determined by the intersection of the line $L \equiv l\alpha + m\beta + n\gamma = o$ with the conic $S \equiv \alpha_0 \beta\gamma + \beta_0 \gamma\alpha + \gamma_0 \alpha\beta = o$, then the conic (i) takes the form

$$\frac{l\alpha^2}{\alpha_0} + \frac{m\beta^2}{\beta_0} + \frac{n\gamma^2}{\gamma_0} + \frac{\beta\gamma}{\beta_0 \gamma_0}(m\beta_0 + n\gamma_0 - l\alpha_0) + \frac{\gamma\alpha}{\gamma_0 \alpha_0}(n\gamma_0 + l\alpha_0 - m\beta_0)$$
$$+ \frac{\alpha\beta}{\alpha_0 \beta_0}(l\alpha_0 + m\beta_0 - n\gamma_0) = o \quad . \quad . \quad . \quad . \quad . \quad (ii).$$

Let the line $L = o$ pass through the fixed point $O'(\alpha'\beta'\gamma')$; then, eliminating l between equation (ii) and the relation $l\alpha' + m\beta' + n\gamma' = o$. the conic (i) takes the form $mS_1 + nS_2 = o$, when

$$S_1 \equiv \beta' \frac{\alpha^2}{\alpha_0} - \alpha' \frac{\beta^2}{\beta_0} - (\alpha_0 \beta' + \alpha' \beta_0)\frac{\gamma}{\gamma_0}\left(\frac{\alpha}{\alpha_0} - \frac{\beta}{\beta_0}\right) - \frac{\alpha\beta}{\alpha_0 \beta_0}(\alpha_0 \beta' - \alpha' \beta_0) = o,$$

$$S_2 \equiv \gamma' \frac{\alpha^2}{\alpha_0} - \alpha' \frac{\gamma^2}{\gamma_0} + (\gamma_0 \alpha' + \gamma' \alpha_0)\frac{\beta}{\beta_0}\left(\frac{\gamma}{\gamma_0} - \frac{\alpha}{\alpha_0}\right) - \frac{\gamma\alpha}{\gamma_0 \alpha_0}(\gamma' \alpha_0 - \gamma_0 \alpha') = o.$$

Hence we derive the theorem,—

If the poles of two sub-polar triangles be determined by the intersection of a variable line passing through a fixed point with a fixed conic circumscribing the triangle of reference, the conic circumscribing the two sub-polar triangles passes through four fixed points.

It will be seen on inspection that one of the points of intersection of the two conics S', S'' is the point $(\alpha_0 \beta_0 \gamma_0)$—the pole of the conic S_0.

A particular case arises if we suppose the variable line L to pass through the point $(\alpha_0 \beta_0 \gamma_0)$. Conic (ii) reduces to

$$\frac{l\alpha^2}{\alpha_0} + \frac{m\beta^2}{\beta_0} + \frac{n\gamma^2}{\gamma_0} - 2l\alpha_0 \frac{\beta\gamma}{\beta_0 \gamma_0} - 2m\beta_0 \frac{\gamma\alpha}{\gamma_0 \alpha_0} - 2n\gamma_0 \frac{\alpha\beta}{\alpha_0 \beta_0} = o \quad . \quad . \quad (iii)$$

subject to the relation $l\alpha_0 + m\beta_0 + n\gamma_0 = o$. By eliminating l we obtain

$$m\beta_0\left(\frac{\alpha}{\alpha_0} - \frac{\beta}{\beta_0}\right)\left(\frac{\alpha}{\alpha_0} + \frac{\beta}{\beta_0} + \frac{2\gamma}{\gamma_0}\right) - n\gamma_0\left(\frac{\gamma}{\gamma_0} - \frac{\alpha}{\alpha_0}\right)\left(\frac{\alpha}{\alpha^0} + \frac{2\beta}{\beta_0} + \frac{\gamma}{\gamma_0}\right) = o,$$

which shows that all conics of this family pass through the four fixed points $(\alpha_0 \beta_0 \gamma_0)$, $(-3\alpha_0 \beta_0 \gamma_0)$, $(\alpha_0 - 3\beta_0 \gamma_0)$, $(\alpha_0 \beta_0 - 3\gamma_0)$.

If the poles of two sub-polar triangles be the circular points at infinity, conic (i) takes the form

$$\alpha^2 + \beta^2 + \gamma^2 + 2\beta\gamma \cos A + 2\gamma\alpha \cos B + 2\alpha\beta \cos C = o.$$

If the two points O_1, O_2 be the extremities of a diameter of the circle ABC, then conic (i) takes the form

$$\lambda \frac{\alpha^2}{\sin A \cos A} + \mu \frac{\beta^2}{\sin B \cos B} + \nu \frac{\gamma^2}{\sin C \cos C}$$

$$+ \frac{\beta\gamma}{\sin B \sin C} (\mu \tan B + \nu \tan C - \lambda \tan A)$$

$$+ \frac{\gamma\alpha}{\sin C \sin A} (\nu \tan C + \lambda \tan A - \mu \tan B)$$

$$+ \frac{\alpha\beta}{\sin A \sin B} (\lambda \tan A + \mu \tan B - \nu \tan C) = o,$$

where $\lambda + \mu + \nu = o$.

Since the equation of any diameter of the circle ABC is

$$\frac{\lambda\alpha}{\cos A} + \frac{\mu\beta}{\cos B} + \frac{\nu\gamma}{\cos C} = o,$$

if the diameter pass through the symmedian point

$$\lambda \tan A + \mu \tan B + \nu \tan C = o,$$

and the above equation reduces to

$$\frac{\sin (B-C)}{\sin A}\alpha^2 + \frac{\sin (C-A)}{\sin B}\beta^2 + \frac{\sin (A-B)}{\sin C}\gamma^2 - \frac{2 \sin A \sin (B-C)}{\sin B \sin C}\beta\gamma$$

$$- \frac{2 \sin B \sin (C-A)}{\sin C \sin A}\gamma\alpha - \frac{2 \sin C \sin (A-D)}{\sin A \sin B}\alpha\beta = o,$$

a conic which passes through the symmedian point of the triangle ABC.

If O_1, O_2 be the extremities of a diameter of the Steiner ellipse

$$\frac{1}{a\alpha} + \frac{1}{b\beta} + \frac{1}{c\gamma} = o,$$

then the conic (i) reduces to

$$\lambda (a^2\alpha^2 - 2bc\beta\gamma) + \mu (b^2\beta^2 - 2ca\gamma\alpha) + \nu (c^2\gamma^2 - 2ab\alpha\beta) = o,$$

where $\lambda + \mu + \nu = o$.

§ 2. The condition that conic (i) should be a rectangular hyperbola is

$$\frac{1}{\alpha_1\alpha_2} + \frac{1}{\beta_1\beta_2} + \frac{1}{\gamma_1\gamma_2} + \cos A \left(\frac{1}{\beta_1\gamma_2} + \frac{1}{\beta_2\gamma_1}\right) + \cos B \left(\frac{1}{\gamma_1\alpha_2} + \frac{1}{\gamma_2\alpha_1}\right)$$

$$+ \cos C \left(\frac{1}{\alpha_1\beta_2} + \frac{1}{\alpha_2\beta_1}\right) = o.$$

Hence, if $O_1 (\alpha_1 \beta_1 \gamma_1)$ be fixed, the locus of O_2 will be the circum-conic

$$\frac{1}{\alpha}\left(\frac{1}{\alpha_1} + \frac{\cos C}{\beta_1} + \frac{\cos B}{\gamma_1}\right) + \frac{1}{\beta}\left(\frac{\cos C}{\alpha_1} + \frac{1}{\beta_1} + \frac{\cos A}{\gamma_1}\right)$$

$$+ \frac{1}{\gamma}\left(\frac{\cos B}{\alpha_1} + \frac{\cos A}{\beta_1} + \frac{1}{\gamma_1}\right) = o \quad . \quad . \quad . \quad . \quad . \quad (iv).$$

If O_1 be the centroid of the triangle ABC, then the conic (iv) reduces to the circle ABC.

Hence the theorem,—

A rectangular hyperbola can be drawn through the middle points of the sides of a triangle and the points in which the sides of the triangle are cut by lines joining any point on the circum-circle of the triangle to the vertices of the triangle.

If O_1 be the orthocentre of the triangle ABC, then conic (iv) reduces to

$$\frac{\cos(B-C)}{\alpha} + \frac{\cos(C-A)}{\beta} + \frac{\cos(A-B)}{\gamma} = o.$$

§ 3 If the circle described about the triangle $D_1E_1F_1$ meet the sides BC, CA, AB of the triangle ABC again in the respective points $D^1E^1F^1$, then the lines AD^1, BE^1, CF^1 are concurrent. Let the co-ordinates of the point of concurrence O^1 be $(\alpha^1\beta^1\gamma^1)$. The vertices of the triangles $D_1E_1F_1$, $D^1E^1F^1$ lie on the circle

$$\frac{\alpha^2}{\alpha_1\alpha^1} + \frac{\beta^2}{\beta_1\beta^1} + \frac{\gamma^2}{\gamma_1\gamma^1} - \beta\gamma\left(\frac{1}{\beta_1\gamma^1} + \frac{1}{\beta^1\gamma_1}\right) - \gamma\alpha\left(\frac{1}{\gamma_1\alpha^1} + \frac{1}{\gamma^1\alpha_1}\right)$$

$$-\alpha\beta\left(\frac{1}{\alpha_1\beta^1} + \frac{1}{\alpha^1\beta_1}\right) = o \quad . \quad . \quad . \quad . \quad . \quad . \quad (\text{v}).$$

From the conditions for a circle, we at once obtain

$$\begin{aligned}\frac{1}{\alpha^1} : \frac{1}{\beta^1} : \frac{1}{\gamma^1} = {} & a(\gamma_1^2\alpha_1^2 + \alpha_1^2\beta_1^2 - \beta_1^2\gamma_1^2) - 2\alpha_1\beta_1\gamma_1 \cos A(a\alpha_1 + b\beta_1 + c\gamma_1)\\ & : b(\alpha_1^2\beta_1^2 + \beta_1^2\gamma_1^2 - \gamma_1^2\alpha_1^2) - 2\alpha_1\beta_1\gamma_1 \cos B(a\alpha_1 + b\beta_1 + c\gamma_1)\\ & : c(\beta_1^2\gamma_1^2 + \gamma_1^2\alpha_1^2 - \alpha_1^2\beta_1^2) - 2\alpha_1\beta_1\gamma_1 \cos C(a\alpha_1 + b\beta_1 + c\gamma_1).\end{aligned}$$

It may be at once verified that if $\alpha_1 : \beta_1 : \gamma_1 = \frac{1}{a} : \frac{1}{b} : \frac{1}{c}$, then $\alpha^1 : \beta^1 : \gamma^1 = \sec A : \sec B : \sec C$, and the circle in this case is the nine-point circle of the triangle ABC.

If $a\alpha_1 + b\beta_1 + c\gamma_1 = o$, then

$$\kappa\left(\frac{1}{b\beta^1} + \frac{1}{c\gamma^1}\right) = \alpha_1^2,$$

$$\kappa\left(\frac{1}{c\gamma^1} + \frac{1}{a\alpha^1}\right) = \beta_1^2,$$

$$\kappa\left(\frac{1}{a\alpha^1} + \frac{1}{b\beta^1}\right) = \gamma_1^2,$$

hence the locus of the point $\alpha^1\beta^1\gamma^1$ is the quartic curve

$$a\sqrt{\left(\frac{1}{b\beta} + \frac{1}{c\gamma}\right)} + b\sqrt{\left(\frac{1}{c\gamma} + \frac{1}{a\alpha}\right)} + c\sqrt{\left(\frac{1}{a\alpha} + \frac{1}{b\beta}\right)} = o \quad . \quad . \quad . \quad (\text{vi}).$$

This result may be stated as follows:—

If lines drawn through the vertices of the triangle ABC parallel to a given line L meet the sides of that triangle in $D_1E_1F_1$, and the circle through $D_1E_1F_1$ intersect the sides again in $D^1E^1F^1$, then the lines AD^1, BE^1, CF^1 are concurrent in the point O^1, and as L turns about a fixed point in the plane ABC, the locus of O^1 will be the above curve (vi).

This quartic curve is the isogonal transformation of

$$\sqrt{a(b\gamma + c\beta)} + \sqrt{b(c\alpha + a\gamma)} + \sqrt{c(a\beta + b\alpha)} = o,$$

a conic inscribed in the triangle formed by drawing tangents to the circle ABC at the vertices of the triangle of reference.

The lines joining the points of contact of the conic with the sides of the circumscribing triangle to the opposite vertices of that triangle are concurrent in the point

$$\left[\frac{1}{b^2}+\frac{1}{c^2}-\frac{1}{a^2},\ \frac{1}{c^2}+\frac{1}{a^2}-\frac{1}{b^2},\ \frac{1}{a^2}+\frac{1}{b^2}-\frac{1}{c^2}\right].$$

If the point $O^1(\alpha^1\beta^1\gamma^1)$ lie on the circle ABC, then the locus of $O_1(\alpha_1\beta_1\gamma_1)$ is a quartic curve whose isogonal transformation is the conic

$$\alpha^2\cot A+\beta^2\cot B+\gamma^2\cot C-2\,(\beta\gamma\sin A+\gamma\alpha\sin B+\alpha\beta\sin C)=o.$$

If the point O^1 lie on the Steiner ellipse

$$\frac{1}{a\alpha}+\frac{1}{b\beta}+\frac{1}{c\gamma}=o,$$

then the locus of O_1 is the quartic curve whose isogonal transformation is the conic

$$abc\,(\alpha^2+\beta^2+\gamma^2)-(a^2+b^2+c^2)\,(a\beta\gamma+b\gamma\alpha+c\alpha\beta)=o.$$

§4. The remainder of the paper is concerned with the cases arising when the poles of the two sub-polar triangles are isogonally conjugate with respect to the triangle ABC. Let a point $O\,(\alpha_0\beta_0\gamma_0)$ and its isogonal conjugate $O'\left(\frac{1}{\alpha_0}\ \frac{1}{\beta_0}\ \frac{1}{\gamma_0}\right)$ be taken, and let their sub-polar triangles be DEF, D'E'F'. Also let

$$p\equiv\frac{\beta_0}{\gamma_0}-\frac{\gamma_0}{\beta_0},\quad q\equiv\frac{\gamma_0}{\alpha_0}-\frac{\alpha_0}{\gamma_0},\quad r\equiv\frac{\alpha_0}{\beta_0}-\frac{\beta_0}{\alpha_0}$$

$$p'\equiv\frac{\beta_0}{\gamma_0}+\frac{\gamma_0}{\beta_0},\quad q'\equiv\frac{\gamma_0}{\alpha_0}+\frac{\alpha_0}{\gamma_0},\quad r'\equiv\frac{\alpha_0}{\beta_0}+\frac{\beta_0}{\alpha_0}.$$

The equation of the line Oo' is

$$L\equiv\alpha\alpha_0(\beta_0^2-\gamma_0^2)+\beta\beta_0(\gamma_0^2-\alpha_0^2)+\gamma\gamma_0(\alpha_0^2-\beta_0^2)=o,$$

which, after dividing out by $\alpha_0\beta_0\gamma_0$, reduces to

$$L\equiv p\alpha+q\beta+r\gamma=o.$$

The sub-polar triangles whose poles are isogonal conjugates are self-conjugate with respect to the conic which is the isogonal transformation of the line joining their poles.

The co-ordinates of the points D, D' are respectively $(O\,\beta_0\gamma_0)$, $\left(O\,\frac{1}{\beta_0}\ \frac{1}{\gamma_0}\right)$, and the equations of EF and E'F' are

$$-\frac{\alpha}{\alpha_0}+\frac{\beta}{\beta_0}+\frac{\gamma}{\gamma_0}=o$$

$$-\alpha\alpha_0+\beta\beta_0+\gamma\gamma_0=o.$$

The equations of the polars of D, D' with respect to the conic

$$S_0\equiv p\beta\gamma+q\gamma\alpha+r\alpha\beta=o$$

are

$$p\,(\beta\gamma_0+\gamma\beta_0)+\alpha\,(q\gamma_0+r\beta_0)=o,$$

$$p\,(\beta\beta_0+\gamma\gamma_0)+\alpha\,(q\beta_0+r\gamma_0)=o,$$

which at once reduce to the equations found for EF, E'F', and so prove the theorem.

The vertices of the triangles DEF, D′E′F′ lie on the conic

$$S \equiv \alpha^2 + \beta^2 + \gamma^2 - p'\beta\gamma - q'\gamma\alpha - r'\alpha\beta = o,$$

and the sides of the two triangles touch the conic

$$\Sigma \equiv \frac{\alpha^2}{pp'} + \frac{\beta^2}{qq'} + \frac{\gamma^2}{rr'} = o.$$

The polars of the points O, O′ with respect to the triangle ABC are

$$\frac{\alpha}{\alpha_0} + \frac{\beta}{\beta_0} + \frac{\gamma}{\gamma_0} = o,$$

$$\alpha\alpha_0 + \beta\beta_0 + \gamma\gamma_0 = o,$$

and these lines meet in the point Ω whose co-ordinates are $(p\,q\,r)$.

Let the sides EF, FD, DF, E′F′, F′D′, D′E′ touch Σ in the points P, Q, R, P′, Q′, R′ respectively: the equations of PP′, QQ′, RR′ are

$$-\frac{\alpha}{p'} + \frac{\beta}{q'} + \frac{\gamma}{r'} = o,$$

$$\frac{\alpha}{p'} - \frac{\beta}{q'} + \frac{\gamma}{r'} = o,$$

$$\frac{\alpha}{p'} + \frac{\beta}{q'} - \frac{\gamma}{r'} = o.$$

Hence the triangle formed by PP′, QQ′, RR′ is the sub-polar triangle of the point Ω′ $(p'q'r')$.

The conic S is the harmonic conic of

$$\Sigma_1 \equiv \sqrt{\frac{\alpha}{\alpha}} + \sqrt{\frac{\beta}{\beta_0}} + \sqrt{\frac{\gamma}{\gamma_0}} = o$$

$$\Sigma_2 \equiv \sqrt{\alpha_0\alpha} + \sqrt{\beta_0\beta} + \sqrt{\gamma_0\gamma} = o.$$

The co-ordinates of intersection of the two conics Σ_1, Σ_2 are*

$$(p'-2,\ q'-2,\ r'-2) \quad (p'-2,\ q'+2,\ r'+2)$$

$$(p'+2,\ q'-2,\ r'+2) \quad (p'+2,\ q'+2,\ r'-2).$$

The lines joining these points are of the form

$$\alpha(q'-\gamma') - (p'-2)(\beta-\gamma) = o,$$

$$\alpha(q'+r') - (p'+2)(\beta+\gamma) = o,$$

and it is easily shown that the co-ordinates of the intersections of the joining lines not lying on Σ_1 and Σ_2 are $(-p\,q\,r)$ $(p\,-q\,r)$ $(p\,q\,-r)$. These are the points in which the corresponding sides of the triangles DEF, D′E′F′ meet. Hence the theorem,—

The intersections of corresponding sides of two sub-polar triangles whose poles are isogonal conjugates determine the vertices of the diagonal triangle of the quadrangle formed by the intersections of the two conics inscribed in the triangle of reference which are the envelopes of the polars with respect to that triangle of points lying on the polars of the poles of the two sub-polar triangles.

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* "Messenger of Mathematics," No. 451, November, 1908, p. 117.

The sides of the triangles PQR, P′Q′R′ pass through the vertices of the triangle ABC, the equations of QR and Q′R′ being respectively

$$\frac{\beta\beta_0}{qq'}+\frac{\gamma\gamma}{rr'}=0,$$

$$\frac{\beta}{\beta_0 qq'}+\frac{\gamma}{\gamma_0 rr'}=0.$$

The triangles PQR, P′Q′R′ are self-conjugate with respect to the following inscribed conic :—

$$\sqrt{\frac{\alpha}{p'}}+\sqrt{\frac{\beta}{q'}}+\sqrt{\frac{\gamma}{r'}}=0.$$

Any point on the conic

$$S_0\equiv\alpha_0\beta\gamma+\beta_0\gamma\alpha+\gamma_0\alpha\beta=0$$

is expressed by the co-ordinates

$$[-\kappa\alpha_0,\ \kappa\beta_0+\gamma_0,\ \kappa(\kappa\beta_0+\gamma_0)],$$

where κ is a variable parameter.

The equations of the sides EF, FD, DE of the triangle DEF are respectively

$$\kappa\beta_0\left(\frac{\alpha}{\alpha_0}+\frac{\beta}{\beta_0}\right)+\gamma_0\left(\frac{\gamma}{\gamma_0}+\frac{\alpha}{\alpha_0}\right)=0,$$

$$\kappa\beta_0\left(\frac{\alpha}{\alpha_0}+\frac{\beta}{\beta_0}\right)+\gamma_0\left(\frac{\gamma}{\gamma_0}-\frac{\alpha}{\alpha_0}\right)=0,$$

$$\kappa\beta_0\left(\frac{\alpha}{\alpha_0}-\frac{\beta}{\beta_0}\right)+\gamma_0\left(\frac{\gamma}{\gamma_0}+\frac{\alpha}{\alpha_0}\right)=0.$$

Hence EF passes through the point of intersection of the tangents to S_0 at B and C; FD passes through the point in which the line joining B to the pole of the conic meets the tangent at C; DE passes through the point in which the line joining C to the pole of the conic meets the tangent at B.

The sides of the triangles D′E′F′ are respectively

$$\kappa^2\beta_0\gamma+\kappa(\alpha_0\alpha+\beta_0\beta+\gamma_0\gamma)+\beta\gamma_0=0,$$

$$\kappa^2\beta_0\gamma-\kappa(\alpha_0\alpha+\beta_0\beta-\gamma_0\gamma)-\beta\gamma_0=0,$$

$$\kappa^2\beta_0\gamma+\kappa(\alpha_0\alpha-\beta_0\beta+\gamma_0\gamma)-\beta\gamma_0=0,$$

and these lines envelop respectively the conics

$$(\alpha_0\alpha+\beta_0\beta+\gamma_0\gamma)^2-4\beta_0\gamma_0\beta\gamma=0,$$

$$(\alpha_0\alpha+\beta_0\beta-\gamma_0\gamma)^2+4\beta_0\gamma_0\beta\gamma=0,$$

$$(\alpha_0\alpha-\beta_0\beta+\gamma_0\gamma)^2+4\beta_0\gamma_0\beta\gamma=0.$$

Hence the theorem,—

If the pole of a sub-polar triangle move on a conic circumscribing the triangle of reference, the sides of the sub-polar triangle will pass through three fixed points, while if the pole move on a straight line the sides of the sub-polar triangle will envelop three fixed conics.

ART. XLII.—*Note on the Geology of Mangaia.*

By P. MARSHALL, D.Sc., Professor of Geology, Otago University.

[*Read before the Otago Institute, 16th November, 1909.*]

THE island of Mangaia is situated in lat. 22° 30′ S. and long. 157° 30′ E. It is thirty miles in circumference. Charles Darwin represents it merely as an island with a fringing reef. It has since Darwin's time often been stated that the island is mainly composed of raised coral rock. The following account is taken from a description kindly forwarded to me by Major Large, the Resident Agent on the island.

The fringing reef is 100 to 300 yards broad, and on its outer side rises steeply from deep water. The inner edge is bounded in most places at high-water mark by overhanging masses of old coral. Sloping up from this is a broken rocky tract, fairly level on top. The road which connects the three coastal settlements is formed on this belt. From this there rises another belt of coral rock with perpendicular cliffs to a height of 60 ft. to 80 ft.; its width is a quarter of a mile, and it is bounded by steep cliffs on its inner side. This is the *makatea* of the Natives. Inside the *makatea* there is a low-lying belt of rich soil, from which the central mountain—the crown of Mangaia—an irregular-shaped flat-topped hill, rises to a height of about 660 ft. The surface of this is formed of hard volcanic clay.

From this it appears that there have been two distinct movements of elevation, when the two coral reefs were raised which now form the rings of coral rock that form the outer part of the island. The low-lying ring of country must have been the lagoon inside the first coral reef. The crown of Mangaia, which consists of volcanic rock, is the old island. Major Large kindly sent me specimens of coral rock and of ferruginous flints that are found in it, and also specimens of volcanic rock from the crown of Mangaia.

The ferruginous flints proved to be nothing more than silicified portions of the coral rock, in which the structure of the coral is still quite distinct in microscopic section. It appears that these flints were not used for making the Native weapons, because of their brittleness.

Several pieces of rock were found to be basaltic scoria in a more or less decomposed state. A more solid piece of rock proved to be a basalt containing relatively large phenocrysts of feldspar (labradorite). The rock contained but little olivine. A Native adze was formed of a very fine-grained rock, which proved to be a typical basalt. Examination of these rocks shows that the island is composed of material quite different from that of Rarotonga and Aitutaki, which I have previously described as composed of alkaline varieties of volcanic rock.

Since the above was written a visit to the island has shown me the accuracy of Major Large's description. The flat-topped hill in the centre appears to mark an ancient sea-level when the island was a submarine shoal. Despite a long period of depression, during which the *makatea* was formed, the summit of the island is now 660 ft. above its original level. The rocks are extensively decomposed. I found nothing but basalt and dolerites.

Art. XLIII.—*The Glaciation of New Zealand.*

By P. Marshall, D.Sc., Professor of Geology, Otago University.

[*Read before the Otago Institute, 14th September,* 1909.]

It is needless at this stage of the observation of the surface features of New Zealand to insist on the fact that in the latest geological times all the present glaciers were much extended, and that numerous glaciers existed where there is now no ice. In regard to fundamentals, in recent years few additions have been made to the amount of information that was possessed by Hutton, Hector, and Haast in the early "seventies."

There has, however, been a large amount of detailed information gained in regard to several of the former glaciers in many parts of the country, and in regard to the actual extent of many of those glaciers. All those surface features due to glacial sculpture which have been recorded and described in other glaciated countries have been recognised in New Zealand, especially in the upland and western districts of Otago and Canterbury.

Generally it may be stated that in the north-west of the Nelson Province signs of glaciation have not been found at a lower level than 4,000 ft. above sea-level, while in the eastern portion of this province, where the mountains do not often exceed 5,000 ft. in height, there appears to have been no important accumulation of ice whatever. Further south, the glaciers that filled the basins of the present lakes Rotorua and Rotoiti had their terminal faces at an altitude less than 2,000 ft. above sea-level. This relatively small altitude is easily explained by the situation of the lakes, for they lie between mountain-ranges, and in country that is continuously high, which afforded a large gathering-ground for snow and ice.

The effects of glaciation are clearly seen in all the large river-valleys of Canterbury. High up on the mountain-sides are seen the terraces with their decided slope outwards from the mountain-axis. In all the valleys *roches moutonnées* are abundant, and are deeply scored with glacial marks. Smoothed rock-surfaces are to be found on every side. These features have been observed and noted by every geologist who has wandered into any of the great valleys. Marshall and Speight have advocated the idea that the glaciers which filled the valleys are also responsible for the overdeepening which these valleys have evidently undergone. In Canterbury it is recognised that the larger glaciers crept through the present gorges into the plains, and that their terminal faces were outside of the mountain regions. Such elevations as Woolshed Hill and Little Racecourse Hill are considered to be portions of the terminal moraines. Only one locality is yet known where the ice approached the east coast: this is at the Taieri, where the well-known moraine extends for some six miles north-east and at least ten miles south-west of the gorge of the river, and stretches three miles east from the plains.

On the west coast the glaciers then, as now, extended to far lower levels than on the east coast. Ice filled all the profound valleys of the western sounds, and in them ice-worn surfaces of rocks, *roches moutonnées*, glacial cirques, hanging valleys, and all the other features of glacial erosion are to be seen in perfection.

Further north the ice extended some distance westward from the foot of the mountain-range. The terminal moraines now form the coast-line at intervals between Ross and Milford Sound, and are not far inland at Hokitika and Greymouth.

These limits of glaciation have been recognised for a long time, and have been embodied in a map published by the Glaciation Research Committee of the Australasian Association for the Advancement of Science.

In a recent bulletin of the New Zealand Geological Survey, No. 7, p. 25, the following statements are made: "The features of the land in the Wakatipu region, and from there southwards to the plains of Southland and eastwards to the sea, are everywhere dominated by evidences of ice erosion on a scale of magnificence that is unknown elsewhere in the Southern Hemisphere, and is perhaps without a parallel elsewhere outside of the polar regions. Each valley and depression contained its own glacier, but all were united in one, forming part of the great ice-sheet that covered the land. Its surface formed a vast plateau through which the tops of the highest peaks appeared, looking like lonely islets in a frozen sea. A striking feature of this gigantic glaciation is the remarkable freshness of the ice-grooved surfaces, the beautiful flowing contours being everywhere sharply outlined in their carpets of native grasses."

P. 40: "Evidences of a continuous ice-sheet can be traced along the main axial divide until we reach Boulder Lake, in Collingwood County. The smooth, rounded contours of the ranges between Wakatipu and the sea, the thick sheet of boulder-clay covering the Henley Hills and the area between Saddle Hill and Dunedin, and the silts and glacial till covering the Timaru and Oamaru areas afford convincing proof that the glaciers also reached the sea on the east coast. The ice-sheet appears to have reached its northern limit near Cook Strait."

P. 43: "The Henley deposit is undoubtedly of glacial origin. It is not a terminal moraine, but a true boulder-clay, the formation of which appears to have been partly subglacial and partly subaqueous. A sheet of boulder-clay of great interest covers all the hills and ridges between Dunedin and Saddle Hill. It consists of stiff yellow clay, which often contains boulders of basalt, phonolite, dolerite, and other igneous rocks." "The question may now be asked, Was the great ice plateau that covered the South Island of New Zealand an extension of the polar ice-sheet? It is almost certain that this must be answered in the affirmative, for whatever cause or causes originated the glacial period in New Zealand would also operate in the higher latitudes. The exploring expedition of last November proved that the Auckland and Campbell Islands had suffered erosion by an overriding sheet of ice that must have had a polar origin."

The only evidences that are offered in support of these sweeping statements in the publication are contained in the above extracts and in a detailed statement of the thickness of the ice in the Wakatipu basin. This is estimated to have been 7,400 ft.

It is advisable here to state the nature of the criteria some or all of which are usually employed in defining the limits of a prehistoric ice-sheet:—

(1.) A more or less continuous line of morainic deposits at the extreme limit of the ice-sheet.

(2.) The occurrence of till or boulder-clay over almost the whole area that was covered by the ice-sheet.

(3.) The occurrence of *roches moutonnées* or rounded hills of solid rock distributed over the area.

(4.) The occurrence of grooved or ice-worn surfaces of rock generally throughout the district that has been covered. Such surfaces will naturally be more numerous and conspicuous where any elevations rise in the path of the ice.

(5.) Boulders of rocks foreign to the locality will be found in great numbers in positions where they cannot have been deposited by streams that formerly existed or on prehistoric sea-beaches.

In the publication to which reference has been made there is no mention of any observations near the coast-line in connection with the subjects of these five headings, with the exception of No. 2. This is very noticeable, for it is explicitly stated that the evidences of glaciation are remarkably fresh even in the mountain regions, where geological processes are most active, and at the level that is described as the upper limit of the ice-sheet, which would therefore be from the first diminution of the glacial covering subject to the healing and concealing processes of nature. It is evident that the lapse of time and the effect of weathering cannot be appealed to as causing the blotting-out or disappearance of other evidence near the coast-line.

It is, however, advisable in a discussion of this kind to consider what observations have been made by geologists in regard to each one of these criteria.

(1.) There is no continuous line of morainic material near the east coast that has yet been described by any geologist. The terminal moraine at Henley is quite isolated. It is opposite the watershed between the Clutha and Taieri basins—that is, opposite to the highest line of country—and it is therefore the most likely place for a glacier to exist if climatic conditions allowed of an accumulation of ice. It is also well known that the material of the moraine dips uniformly to the west at an angle of 15° to 20°. The inclination is constant from Henley to a point three miles to the east. Such an inclination means that the Henley side is now 5,000 ft. lower than when deposited, or that the other side is higher by that amount, or that one is higher and the other lower by 2,500 ft. than in their original position. This shows that earth-movements of some importance have taken place subsequently to the deposition of the moraine, and this may accoun for its present low-lying position. The materials of the moraine have often been described, and its nature is well known to geologists. Its structure is remarkably similar to the morainic material partly assorted by water through which the Tekapo and Pukaki Rivers flow when they issue from lakes of the same names. The great local thickness—800 ft. at least—and the abrupt termination in all directions show that this mass of fragmental material is not a boulder-clay—a conclusion that would naturally be drawn from an inspection of its material alone. It is only necessary to say, in regard to the latter point, that in many places for great thicknesses, especially on the landward margin of the moraine, there is no clay, but merely an unassorted mass of large and small angular pebbles.

A moraine has been described in the Leith Valley. It is a mound 8 ft. high and a few hundred yards in length. It contains no schist boulders, but some andesite is said to have been found in it. I have seen no specimen of this rock in it; neither do I know of any occurrence of andesite in the Leith Valley basin above this point. There appears to be no special evidence in favour of the glacial origin of this material. At all events, even if a glacial origin could be proved for the material of this mound, 8 ft. by 5 chains, such an occurrence can hardly be seriously used as an argument in evidence of the existence of an ice-sheet in eastern Otago.

(2.) Boulder-clays: The coastal area from Timaru to Kaitangata has been examined by numerous geologists. Of these, Hector, Hutton, Haast, McKay, and Park have repeatedly failed to record the occurrence of any till or boulder-clay. Hutton regarded all the surface clay of South Canterbury and North Otago as a marine silt. Haast described it as a loess, and his description has been strongly supported by Hardcastle, and adopted by Heim and Speight. Park, in 1904, referred to the Oamaru loess as yellow silts. The loess of Timaru and Oamaru cannot be distinguished from the similar deposits that form a nearly continuous covering over the Canterbury Plains, and extend to the height of 800 ft. on Banks Peninsula.

My own microscopic examination of this material strongly supports Haast's loess theory. Not only have I seen under the direction of Mr. Hardcastle a few pebbles of small size of well-rolled material, but also well within the mass of the deposit a small amount of bog-iron ore, which was formed in small depressions of the surface on to which the dust was blown from the river-beds.

Microscopic examination shows that the loess consists of minute rounded grains, mostly of quartz, and this is very characteristic of wind-blown material.

The clays about Dunedin are of a very different character. In all cases the only recognisable mineral grains that they contain are those of the most resistant minerals contained in the underlying rock—a matter that at once suggests that they have been formed *in situ*. That this explanation is in many cases correct is proved by the occurrence of sections which show the gradual degradation of the rock into clay. One that is particularly instructive is to be seen at the top of Roslyn, where the Rattray Street tramway passes through a cutting at the top of the hill. The boulders in the clay and on its surface are in almost all cases identical in composition with the sound rock below. In those cases in which this identity of nature is not found the boulders belong to another adjacent lava-flow that lies above it; but there are very few instances of these.

There are a few places at relatively low levels where there is a layer of well-rounded pebbles and boulders beneath the clay. These mark old marine shore-lines. In previous publications it has been shown that the present shore-line bears unmistakable evidence of elevation, for in many places, especially at Sea View, there are marine terraces now some 200 ft. above sea-level. The clay that covers the boulders in the localities referred to has been washed down the hillside on to them. In a typical instance at Caversham the clay that covers the boulders consists almost entirely of quartz grains and remains of *Foraminifera*. These are also the main constituents of the underlying rock and of the surrounding rock over a small area. Although this marine sandstone has quite a small outcrop, and is surrounded by volcanic rock, there is very little admixture of other material that could have been derived from volcanic rocks.

(3.) *Roches moutonnées*: No geologist has yet pointed to or described in any scientific publication any *roches moutonnées* near the coast-line. Until such features have been described and the descriptions discussed, it must be accepted that there is no positive evidence in regard to this. No appeal can be made to the blotting effect of weathering if the statement is true that "a striking feature of this great glaciation is the remarkable freshness of the ice-grooved surfaces."

In the coastal ranges near the Nuggets the development of the many subsequent or strike stream-valleys, eroded to a great depth in hard rocks, is an undoubted proof that those hills have been submitted to uninterrupted stream erosion for a great lapse of time. I have failed to see any effect of glacial erosion in the coastal hills near Dunedin, Timaru, Oamaru, Taieri Mouth, or between the Nuggets and Waikawa, or in the Hokonui Hills.

Mr. Hardcastle has cited the north-west face of Mount Horrible, near Timaru, as an example of glacial erosion. The form of this slope and that of the valley of which it forms one of the sides are, however, quite different from those found in glacial areas, and appear to me to be those of a typical valley and escarpment formed by stream erosion. The typical glacial topography is unknown in the coastal regions, and has not been described in two Geological Survey Bulletins dealing with Central Otago.*

(4.) Glacial pavements: There have been no descriptions of ice-striated surfaces of rock or of boulders. Hutton mentions some that had been stated to be ice-worn. He was, however, able to convince contemporary opinion that the grooves were not due to ice, but to unequal weathering of the rock. Actual experiments with artificially polished rock-surfaces of the same kind of rock as that which he mentions have convinced me that these irregular, curved, and branching grooves are produced by chemical reagents which decompose certain of the rock-constituents.

(5.) Erratic boulders: No foreign boulders have yet been discovered on the Dunedin hills or elsewhere on the coast. It is absolutely impossible that boulders of schist should be entirely absent if the country had been covered by an ice-sheet that radiated from Wakatipu or from some other point on the main divide, for the whole country is formed of schist to within a very few miles of Dunedin. The importance of this is realised when the results of the late Antarctic expeditions are recalled. In South Victoria Land the coastal country round the bases of the great volcanic cones and well up on their flanks is strewn with granite blocks and other rocks brought apparently from great distances. At the Gaussberg, where the ice completely covers the mainland, so that all the coast and even the mountain-tops are invisible, it is still found that the Gaussberg itself is strewn with boulders of much variety brought from the hidden continent. Similar results were obtained in Graham Land by Arctowski. The Swedish expedition in Louis Philippe Land also found numbers of erratic blocks in that ice-bound area.

Much emphasis has lately been laid upon the thickness of the ice in the Lake Wakatipu basin,† and upon its effect in removing and transporting material. In general it is well to acknowledge the great extent to which these descriptions have added to our knowledge of the details of glaciation of the district. There are a few matters to which exception may be taken. It is perhaps unfortunate that the Arrow basin should be called a "cirque," for this term is almost restricted to the amphitheatre at the head of a glacial valley. The Arrow basin is at the junction of at least two glacial valleys of considerable length.

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* Since the above was written, Saddle Hill, Mount Watkins, and other points have been called *roches moutonnées*. The absence of polished and grooved rock-surfaces, and the large number of loose boulders on the summits, appear sufficient to disprove this. These hills are volcanic plugs.

† Bulletin No. 7, N.Z. Geological Survey (New Series), p. 36.

The lateral thrust of the Greenstone Glacier is a difficult matter to understand.* The fact that the Greenstone River flows for five miles of its course through a profound narrow gorge before it joins the Caples appears to be a sufficient proof that the ice of the Greenstone Glacier never passed into the Wakatipu basin. Such a conclusion is strongly supported when it is recognised that the upper Greenstone Valley has a direct continuation to the Mararoa over a pass formed of stratified gravels only a few hundred feet high. Large moraines exist at the lower end of the Mavora Lake. The ice from the Caples undoubtedly joined the Lake Wakatipu Glacier and deposited morainic matter at Rere Lake, but it did not join it at right angles, and cannot have exerted the thrust which is stated to have produced such important effects on the opposite slopes of the Richardson Mountains. Such a thrust is hard to understand, for it is known that the ultimate strength of ice is so small that it would be reduced to the physical state of a fluid long before the pressure was sufficient to bend or break the least-resistant schist. The described effect of the Von Glacier is equally difficult to follow, for there is a low pass from this valley to the Oreti, and it is certain that the Wakatipu ice, if it reached the thickness, would have flowed over into the Oreti, for it is stated that it "strode over" Mount Nicholas, which is 4,827 ft. above sea-level. There was certainly no opposing mass of ice of great magnitude to prevent an overflow into the Oreti Valley.

At the present time it is rash to make assertions as to the source of the boulders found in moraines, for nothing is at present known of the structure of the country at the head of the Dart or even of the Shotover. In the case of the former, at least, it is quite possible that gabbros and other plutonics may exist, for they are known on the western side quite close to the watershed. It is still more likely that greywacke rocks may yet be found in many localities within the Dart watershed.

The actual thickness of the ice is stated to have been 7,490 ft. near the Kingston end of Lake Wakatipu. Judging from analogy with the surface of the Greenland ice-sheet, the slope of the upper surface of the Wakatipu Glacier, even if it is regarded as an ice-sheet, cannot have been less than 90 ft. per mile to the west of this point. Mount Crichton is about twenty-five miles away from it in the direction of the flow of the ice, and the surface of the ice there would be 2,250 ft. higher. In other words, the ice-surface would be 9,950 ft. above sea-level. As Mount Crichton is only 6,185 ft. high, the ice would have been 3,765 ft. above its summit. To any one who has ascended the hills around Lake Wakatipu it is evident that ice has never flowed over their tops. One of the first effects of the movement of an ice covering is to remove all loose blocks and boulders: but when it melts it will leave behind a few foreign boulders which it has carried with it from elsewhere. The photograph on page 80,† of Mount Aurum, which is 7,315 ft. high, shows that it has not been covered by a moving sheet of ice. Every tourist knows of the litter of loose blocks on the summit of Ben Lomond, which is 5,967 ft. high. I have found the same thing on the top of the Livingstone Mountains, and on that of Mount Dick, 6,021 ft., which rises above the point where Lake Wakatipu begins to shallow. The only summit mentioned in the report,* apart from the Hector Mountains, as showing ice erosion is Mount Nicholas, 4,827 ft. high. I have personally seen no effect of ice erosion due to a moving ice-stream at a greater height than 4,000 ft. on Mount Dick or 5,000 ft. on Ben Lomond.

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* Bulletin No. 7, N.Z. Geological Survey (New Series), p. 31.

† *Loc. cit.*, p. 80.

There is here evidently a difference of opinion as to facts; yet the aspect of the Tooth Peaks, near the Greenstone; of the Bayonet Peaks, 5,213 ft., at Halfway Bay; of the Cecil Peak, 6,477 ft.; of the Walter Peak, 5,946 ft., is in every case sufficient to prove to a geologist that none of these peaks have been covered by ice.

If we proceed still further into the hinterland there is everywhere the distinct difference between the glaciated topography of the lower heights and that of the unglaciated topography above, as is most clearly seen in the Routeburn, the head of which is situated on the main watershed, where the ice must have had its greatest thickness. The statements that have been made show that a maximum thickness of 5,240 ft. of ice is all that can be allowed for the great Wakatipu Glacier. Even this thickness will probably appear surprising at first, and may even seem to justify the statement that an ice-sheet overspread the lowlands. It is therefore as well to compare this with the probable thickness of the ice of our present existing glaciers.

In the first place it must be recognised that when an ice-sheet descends to a low level or has a great thickness there is no reason to conclude that all the country, or even adjacent valleys, are similarly affected.

The Tasman Glacier has its terminal face at present 2,358 ft. above sea-level, and the terminal face of the Franz Josef Glacier is 697 ft. above sea-level. Yet there are in each case neighbouring valleys either without ice or with only small glaciers at their heads. On the western side the Douglas River rises to over 4,500 ft. before it disappears beneath the ice of the Marchant Glacier; on the east side the Murchison rises to 3,308 ft. and the Cass to 5,209 ft. before the glacier is reached; while further south, on both sides of the main range, there are scores of valleys rising with gently sloping floors to 3,500 ft., and yet they are innocent of glaciers.

The mere mention of these facts shows that it is obvious that the height of the valley-floor above sea-level does not settle the question as to whether the valley will be occupied by a glacier. It is also obvious that the existence of long glaciers in some valleys does imply that other neighbouring valleys will be filled with ice. It is an undoubted fact that the size of the *névé*, the slope of the valley-floor, the amount of snowfall, are all characters that have great importance in relation to the size of glaciers.

It is seldom realised that the ice in our present glaciers is of great thickness. Actual estimates based on measurements in New Zealand are not at present available. It is, however, probable that we shall not err gravely if we adapt measurements that have been made in Switzerland to the slightly different dimensions of our own glaciers. Of all the Swiss glaciers the Aar appears to be most similar to the Tasman; but its length is only ten miles, while that of the Tasman is 17·5 miles. The thickness of the ice in the Aar Glacier is 1,312 ft. (400 metres: De Lapparent). If the thickness of the Tasman has the same ratio to its length as that of the Aar, it must be 2,296 ft.

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* Bulletin No. 7, N.Z. Geological Survey (New Series) p. 31.

It is, however, possible to make an independent estimate of the thickness of the ice. It is well known that the ice of a glacier decreases somewhat rapidly in thickness towards its lower end. This is a natural result of the fact that at the low altitudes the relatively high temperature melts it. The rate of melting in Switzerland is between 19·7 ft. and 26·2 ft. per annum. It is probable that the rate is somewhat higher in New Zealand, for the latitude is lower, and in consequence the rays of the sun are stronger and the amount of summer rainfall is higher—and it is known that the rainfall is perhaps the most important agent in melting the ice. The rate of ablation, or of lowering of the ice-surface, mainly due to melting, is in Switzerland 19 ft. to 25 ft. per annum (De Lapparent). Here it is certain that the rate of ablation will not be overestimated at 20 ft. per annum. The rate of flow of the ice of the Tasman Glacier is 12 in. per annum at the Malte Brun spur—say, opposite the De la Beche bivouac. This was measured in summer; and in glaciology the summer rate is supposed to be twice that of the winter rate. The average throughout the year at this point is, then, 9 in. per day. The Mueller Glacier 40 chains from its terminal face moves at the rate of 2·9 in. per day on an average throughout the year. We shall not underestimate the rate of flow between the De la Beche bivouac and the terminal face of the Tasman Glacier at 6 in. per day on an average throughout the year. In other words, the ice travels over its bed in this part of its course a distance of 182·5 ft. per year. If the ablation is supposed to commence to be in excess of accumulation at the De la Beche bivouac, and to amount to 20 ft. per annum at the terminal face, the average rate of ablation between these points will be 10 ft. per annum. If the onward movement is 182·5 ft. per annum, and the terminal face is eleven miles distant, the ice at the De la Beche bivouac will take $\frac{5280}{182 \cdot 5} \times 11$, or 311·3 years, to reach the terminal face.

During this time its thickness will decrease by 311·3 × 10 ft., or 3,113 ft. In other words, this method shows us that the ice of the Tasman Glacier is 3,113 ft. thick at the De la Beche bivouac. Since the surface of the ice is at this point 4,782 ft. above sea-level, its lower surface must on this estimate be 1,669 ft. above sea-level, or 689 ft. lower than the valley-floor at the terminal face. Or, expressed differently, the Tasman ice must lie in a trough-shaped basin similar to that of Lake Wakatipu.

Whichever of these estimates of the ice-thickness is taken—2,296 ft. or 3,113 ft.—it is, at any rate, evident that the thickness of the ice in the Tasman Valley is very considerable: but it is well known that it has little or no effect on the climate of the surrounding country, not to mention New Zealand as a whole.

Viewed in the light of these facts of the low level and thickness of ice in a valley of the present day, the statements as to the low level and thickness of the ice in the Wakatipu Valley during the glacial extension becomes less impressive.

Whatever may be the origin of the Wakatipu basin, it is, at any rate, evident that its form has not been changed by any faulting since the ice that once filled it disappeared. In the absence of definite information we are justified in assuming that the terraces round it are actually horizontal, and this would almost certainly not be the case if faulting had occurred. Soundings show that the floor of the lake is so destitute of irregularities that no fault scarp can cross it. The reversed slope of its lower end must, then, have existed when the basin was filled with ice.

There is also no question that the main stream of ice flowed towards Athol. In order that there should have been any flow in that direction, the upper surface of the ice must have sloped towards Athol. The Tasman Glacier has a slope of 229 ft. per mile in its flattest part. The Greenland ice-sheet has a surface slope of 220 ft. per mile for the first 3,281 ft. of rise on its eastern side, and 93 ft. per mile for the next 3,281 ft., according to Nansen.

If we take the slope of the Wakatipu ice at 100 ft. per mile above Kingston, and 300 ft. per mile from there onwards, we are not likely to err much.

We will suppose the thickness to be 7,490 ft. at a distance of five miles from Kingston, where the upward slope of the lake-floor begins. At Kingston, five miles away, the thickness of the ice would be 1,265 ft. less owing to the rise of the lake-floor, and an additional 500 ft. less owing to the downward slope of the surface of the ice. That is, at Kingston the thickness will be reduced by 1,765 ft., and will therefore be 5,725 ft. This reduction in thickness must be due to melting, and it amounts to 388 ft. per mile. There is no reason to suppose that the rate of melting would decrease below Kingston, and, if it did not increase, the terminal face of the ice would be 5,725 ÷ 388, or fifteen miles away—that is, at Athol. Here the terminal moraine is actually situated. This estimate is based on the supposition that the reversed slope had then its present form. It is quite possible that it owes its steepness to the deposition of morainic matter which took place when the ice began slowly to retreat. If so, the reversed slope must be supposed to extend from the floor of the lake opposite Mount Dick to the Dome Pass, where the rock-surface is 1,300 ft. above sea-level. The end of the slope at Athol will then be 1,565 ft. above its commencement twenty miles away. If an average slope of surface of 150 ft. per mile be adopted, 3,000 ft. of thickness is accounted for within this distance. The reduction in thickness is therefore 1,565 ft. + 3,000 ft. at this point, which leaves 2,925 ft.; and with a slope of 150 ft. per mile the terminal face would be near Lumsden. At this place there is not a terminal moraine, nor is any known between it and the sea-coast. With my estimate of 4,000 ft. of ice, the terminal face would, under similar conditions of slope, be at Athol.

The result of this inquiry is, at any rate, of such a nature as to prove emphatically that, with such a great thickness of ice in a valley glacier of enormous dimensions, all comparison with an ice-sheet is fallacious.

The statement that the imaginary ice-sheet of New Zealand was connected with another ice-sheet that simultaneously extended northwards from South Victoria Land is not at present supported by any evidence. At first sight it appears to be reasonable to assume that a glacial advance in New Zealand must have been due to some cause that would have affected lands in the south in a similar manner. This, however, is a conclusion that we are not justified in adopting. If a comparison is made with North America, we find that at the time that ice advanced to a latitude of 37° 30′ in the Mississippi Valley, where now a mild, temperate climate is experienced, Alaska was largely free from ice except on or about the mountains, though now it experiences a climate of great severity. To take another instance, Europe during the period of maximum ice-advance was in the west covered by an ice-sheet as far south as the Thames Valley in England, and to the parallel of 50° north latitude in Poland. At the same time, in northern Siberia, at Werchojansk, where the mean annual temperature is now 1·4° Fahr., and the January temperature is —54·4° Fahr., the surface of the land was not covered with ice.

American geologists at the present time believe that the glacial advance took place at different times in different parts of the glacial region. It was earliest in the west, spread eastwards, and is now at its maximum in Greenland.

Another wholly different line of reasoning will naturally make us hesitate to adopt the idea that a reduction of temperature in New Zealand, associated with a similar reduction in South Victoria Land, would cause an ice-sheet from the former to extend northwards to the latter. Captain Scott, as a result of the " Discovery " expedition, recognised that the Great Barrier during the greater glaciation in the south extended over the whole of the Ross Sea . and this is the greatest ice-extension in the south that has yet been suggested by any of those who have visited these regions. The Ross Sea, it must be remembered, is a relatively shallow area of water, for only two soundings have been made that indicate a greater depth than 300 fathoms. Captain Scott states that at the time of this ice-extension the mean temperature must have been higher than to-day. This is accepted as a " natural conclusion " by Philippi, and is also adopted by David.

It therefore appears that a decrease of mean temperature in New Zealand was not necessarily associated with a lower temperature in South Victoria Land ; and, even if there was this association, a glacial advance would probably not result.

There is at present no known instance of a continental ice-sheet extending far over deep oceanic water. That of Greenland stops short of the coast everywhere except at the heads of some of the fiords. In South Victoria Land the Great Barrier terminates in water that is almost everywhere less than 300 fathoms. The " Belgica " expedition, in longitude 90°, as it approached the edge of the ice got frequent soundings less than 300 fathoms. Bruce, as he approached Coats Land, got two soundings less than 200 fathoms. The German expedition in the neighbourhood of Kaiser Wilhelm II Land found similarly shallow water : in two cases the depth was less than 200 fathoms. Thus, even in this greatest known of ice-sheets the northern face of the ice in no place where soundings have been made extends into deep water—in fact, it nowhere extends beyond the shallowest fringe. The importance of this is realised when it is stated that, so far as known, 1,400 miles of water more than 1,500 fathoms deep separates the Ross Sea from New Zealand.

It is also a remarkable fact that the ice seldom extends from island to mainland except where the water is quite shallow. There are many instances of this in the south. The Palmer Archipelago, Coulman Island, the Balleny Islands, are all examples. In the north, Spitzbergen is separate from Greenland, while its islands and those of Franz Josef Land are separate from one another. Still more remarkable, Grinnell Land is not united to northern Greenland, though the strait between them is extremely narrow and shallow. In Europe, the Scandinavian ice-sheet extended to Britain during the Pleistocene glaciation. As the water of the North Sea is almost everywhere less than 100 fathoms deep, this cannot be quoted as an instance of the extension of an ice-sheet across deep water, especially as geologists agree that at that time the whole region was more elevated. A consideration of these facts shows us that remarkably strong proof is necessary before we are justified in countenancing the idea that New Zealand and South Victoria Land were in the past united by an ice-sheet.

No geological evidence of this connection has yet been put forward, unless we accept the statements of the thickness of ice at Wakatipu as an evidence. Even if we accept the statements previously quoted in regard to this, it is known that there are no surface-features that show that this ice ever extended to the coast. The stated union of this supposed mass of ice with an imaginary extension of the South Victoria ice is nothing more than a guess. If evidence is wanted in its favour, it must be sought mainly on the islands between New Zealand and South Victoria Land. If the ice-sheet extended northwards as suggested, it must have passed over these islands, and on their surface should be found the usual effects of a moving sheet of ice. It is also reasonable to expect to find similar effects of a southern ice-sheet on the low-lying parts of the southern and eastern coast-line of New Zealand.

In 1907 an expedition from New Zealand visited these islands with the object of studying all their natural features. The geologists attached to the expedition paid special attention to the evidence that the surface features of the islands offered in favour of or against the idea of a period of glaciation. The decision was quite unanimous in regard to this matter. All were agreed that there was every indication that glaciers had flowed out radially from the higher lands, and had eroded the deep valleys that now form secure harbours. Agreement was quite as unanimous that the islands showed no indications that they had been subject to the erosion of a sheet of ice of polar origin: there are no erratics, or perched blocks, or rocks of foreign origin; there are no ice-worn surfaces on the hill-tops; there was no development of that peculiar topography characteristic of the work of an ice-sheet. The whole aspect of these islands was considered to negative the idea that a polar ice-sheet had passed over them. There is absolutely no evidence that an ice-sheet from the south reached New Zealand: there are no rocks from that land described; there are no moraines on the low-lying coastal lands; there are no ice-worn surfaces near the coast; there are no characteristic features of glacial erosion near the southern coast.

There is yet another line of reasoning, widely different from any of the preceding. It depends upon the well-known peculiarities of the fauna and flora of the outlying islands in the south. The amount of material available in connection with this matter is very great, and in this paper it is impossible to do more than state the general conclusions. Many species of birds belonging to genera well known in New Zealand and not characteristic of its colder districts have developed peculiar modifications that indicate that the different island groups have been isolated for a long period, and during this isolation have not been subjected to a specially cold climate. Exactly similar results have been arrived at from a study of the plants: but in this case there are genera that are unknown outside the islands.

Geologically interpreted, these facts mean that any elevation that has affected these islands since at least the Pliocene period must have been very slight, for an elevation of less than 1,000 ft. would connect the Auckland Islands with New Zealand, and the striking peculiarities of its animals and plants would, if such an elevation had taken place, have entirely disappeared.

GLACIATION OF THE NORTH ISLAND.

In a paper read at the last meeting of this Institute a statement was made about glaciation in the Ruapehu region. The evidence offered in proof of this glaciation consisted in the occurrence of supposed boulder-clay between Utiku and Waiouru, and the so-called glacial topography on the hills near Taihape.

In regard to the topography, the statement was made that the form of the surface features has only lately been revealed, owing to the effect of the advancement of settlement, and the consequent destruction of forest which previously concealed it. This is certainly not true of the country between Turangarere and Ruapehu, a distance of fifteen miles, which has always been open grass land, and must have been crossed by any supposed glacier which extended from Ruapehu to Utiku. Yet this country has been visited by numerous geologists, all of whom have failed to record any indication of glacial topography. The last of these, Mr. Speight, in an article on the geology of the Tongariro National Park, makes no mention of any glacial features on Ruapehu or the surrounding country outside the area of the present glaciers. The country between Ruapehu and Waiouru consists near Waiouru of river-gravels covered with a thin deposit of volcanic matter, and nearer to the mountain lava-flows take its place. Southwards from Waiouru, hills for the most part flat-topped, and all formed of Cainozoic rocks of late Miocene or Pliocene age, extend to the limits of the supposed glaciation. Near Waiouru the flat-topped hills have a stratum of hard shell-limestone forming the summit. This dips south-eastward 10°, and on its north-westward face there is a steep scarp such as is normally formed in such country by stream-action. I have carefully examined the surface of two of these scarps, and I can assert that they bear no signs whatever that they have been submitted to glacial action. The topography of the land near Taihape does not in any way differ from that of country of a similar age and structure in the neighbourhood of river-valleys in many other districts.

In many places in the Hautapu Valley and other river-valleys hillocks of many different sizes and altitudes are covered with a deposit that is at times well-stratified gravels with boulders of many sizes, and in other places finer and more clay-like deposits, still with some boulders in them. These are the "boulder-clays" of the paper referred to.

Road-cuttings outside of the Hautapu Valley and other river-valleys do not show these gravels or clays. The boulders in the deposits of the Hautapu Valley consist, except for a few fragments of Cainozoic rock, entirely of andesitic blocks, and doubtless come from Ruapehu. My observations showed that the blocks are not markedly angular, and no striated boulders have yet been found in the deposits.

The occurrence of these gravels and boulders is easily accounted for. The whole of this part of the land has been elevated between 2,000 ft. and 4,000 ft. within the latest Cainozoic times. During the movement of elevation the rivers have been filing their way downwards. When the upward movement temporarily ceased or was relatively slight, the rivers widened their beds, and deposited gravels or finer matter over their flood-plains. Volcanic action being then in progress, eruptions provided fine and coarse matter in a most irregular mixture, as at Martinique and St. Vincent. When the upward movement again became more rapid they filed their beds down; and during another period of little movement the old flood-plain was dissected until in some places no trace remains of it except a few isolated hillocks. This perfectly normal action is in all countries known to account for the occurrence of gravels and other river-deposits at many different levels in the same valley. It has been stated that the boulders referred to are larger at Utiku than they are nearer to Ruapehu. My observations certainly do not agree with this. I saw larger boulders at Turangarere than elsewhere; and accurate comparative measurements are certainly necessary to establish the reverse statement.

The occurrence of the largest boulders at Utiku proved too much for the glacial theory, for the material was described as subglacial, and hence would be subject to wear which would be greater the further it was moved.

It may be objected that the source of the Hautapu is not at present to be found in Ruapehu. While this is true, it is a fact that the source of one branch, the Waiouru, is in the volcanic gravels derived from the mountain. At any rate, this objection is more apparent than real. It must be obvious that when the elevation of this area began, the streams from Ruapehu would flow radially outwards as they now do from Mount Egmont. As elevation and erosion continued, interference of stream-courses would result. One effect of this is to be found in the present course of the Wangaehu, which now takes nearly all the western drainage of Ruapehu. The air gap at Waiouru, through the Cainozoic country, may be cited in proof of this, as well as the similar air gap at the head of the Mangaio and of the Turakina.

The mountain-ranges of the North Island have been studied by a number of geologists from time to time, but none of them have recorded any instances of the erosive effects of glaciation. The present writer is familiar with the features of the following mountain-ranges—Rimutaka, Tararua, Ruahine, Kaimanawa—as well as the volcanoes Ruapehu, Ngauruhoe, Tongariro, and Egmont. As he has made many expeditions into the glaciated districts of Otago, Westland, and Canterbury, he is acquainted with the glacial features of mountain-ranges, and can assert, as has been done by others, that the North Island mountains have not been glaciated, or have not supported glaciers of any size at any time in the later geological periods. Neither in the paper to which reference has been made nor in any other publication has there been any mention of glacial valleys, ice-worn surfaces, erratic blocks, or moraines. In the absence of these there is ample justification for geologists to refuse to accept the statement of the past existence of a huge glacier extending over forty-five miles of country to explain the formation of a thin deposit of clay with boulders in it, and of gravels, the occurrence of which can be readily explained by a simple appeal to ordinary geological action.

SUMMARY AND CONCLUSIONS.

A. That an ice-sheet did not reach the east coast is proved by—
  (1.) The absence of moraines near the coast, except at the landward end of the Taieri Gorge, where there have been important earth-movements.
  (2.) The absence of till and boulder-clay. The substances that have been claimed as being of this material are—
    (*a*.) Loess in Canterbury and North Otago;
    (*b*.) Residual clays from volcanic rocks at Dunedin;
    (*c*.) Moraine and valley-trains at the Taieri;
    (*d*.) Old sea-beaches at Caversham and at Green Island.
  (3.) Absence of *roches moutonnées* near the coast-line.
  (4.) Absence of striated glacial pavements near the coast-line.
  (5.) Absence of erratics and striated boulders.
  (6.) Absence of a glacial topography in all coastal districts.

B. The ice of the Wakatipu Glacier:—
  (1.) The occurrence of thick ice in one valley does not justify the conclusion that the ice extended over the surrounding country.

(2.) The thickness of the ice in the ancient Wakatipu Glacier appears less impressive when it is realised that the ice in the Tasman Glacier is at the present day 2,000 ft. thick, and that its floor is only 1,600 ft. above sea-level.

(3.) If the ice was 7,940 ft. thick at the Hector Mountains, and if it had the same surface-slope as the Greenland ice-sheet, it must have extended far over the tops of all the western mountains. These, however, show no signs of having been covered by moving ice.

(4.) The reversed slope of the Wakatipu basin must have existed during the glaciation. This implies a rapid thinning, which must have been due to surface-melting. Adopting the surface-slope of the eastern side of the Greenland ice-sheet, the terminal face cannot have been east of Lumsden.

(5.) The author's estimate of the level of the surface of the ice is 4,000 ft. at Mount Dick. The terminal face would then be at Athol.

(6.) No ice erosion has been described in the Hokonui Hills, nor any moraines or erratics in the Waimea Valley.

C. The suggested extension of the Antarctic ice-sheet :—

(1.) At the present time the ice extends nowhere into deep water.

(2.) There was no ice-sheet in Siberia when there was an ice-sheet in central Europe.

(3.) There was no ice-sheet in Alaska when the Mississippi Valley was glaciated.

(4.) The glaciated portion of North America was not covered by ice simultaneously in all its parts.

These facts show the worthlessness of general statements in regard to glaciation of southern lands.

(5.) There is an absence of all effects of the erosion of an ice-sheet at the Auckland and Campbell Islands.

(6.) No erratic blocks from South Victoria Land have yet been found in New Zealand.

D. The suggested glaciation of the North Island is disproved by the following :—

(1.) The mapping of the river-courses shows no indication of the existence of a glacial topography.

(2.) No striated rock-surfaces.

(3.) No glacial moraines.

(4.) No erratic blocks with striations.

(5.) No *roches moutonnées.*

(6.) The boulder-clays referred to are deposits laid down by rivers that flowed from active volcanoes during periods of activity.

(7.) The deposits at different heights are due to rivers; for, as the land was gradually raised, the base-level of erosion would lie deeper and deeper in the rocks, and portions of the different base-levels would be left at different heights.

(8.) No valleys with the characteristic forms of those due to glacial erosion have yet been described on Ruapehu.

(9.) No glacial valleys have been described in other parts of the North Island.

In general the writer sees no reason to depart from the opinion long held by all New Zealand geologists that the amount of Pleistocene glaciation of New Zealand did not attain to the magnitude of an ice-sheet. On the western side of the South Island the ancient glaciers reached the coast-line in many places. On the eastern side they threaded far through the mountain-valleys towards the coast. This result happens to be in harmony with the descriptions that have been written in regard to the glaciation of Tasmania and Australia.

Art. XLIV.—*Botanical Evidence against the Recent Glaciation of New Zealand.*

By Geo. M. Thomson, F.L.S.

[*Read before the Otago Institute, 22nd September,* 1909.]

In his presidential address recently (11th May, 1909) delivered before our Institute, Professor Park stated that "during the progress of his geological work he had been fortunate enough to obtain evidence to show that New Zealand at one time had a glacial period similar to that of the Northern Hemisphere. He had been able to prove that Otago and the greater part of the South Island were covered with a continuous ice-sheet, probably an extension of the South Polar ice." This glaciation occurred, according to the President, in the Pleistocene period.

It seemed to me, at first sight, impossible to explain many facts in connection with the existing flora of New Zealand in face of such a pronouncement, and I have accordingly sought to test the accuracy of this theory from the botanical standpoint. Such evidence as is available seems to me to be quite opposed to such a theory.

Professor Park's claim means that the greater part of the South Island (which, according to him, was only separated from the North Island in the Pleistocene period) was at that time covered with an ice-sheet (exceeding 7,400 ft. in thickness in the Wakatipu basin) synchronous with that which covered the Northern Hemisphere. To quote his own words as to the effects of such an ice-sheet, "The forests were overwhelmed and completely obliterated, the animals and men inhabiting . . . areas retreated before the terrible blighting wall of ice. . . . The evidence that this mass of ice had been all over Central Otago was so fresh that they might easily imagine it had retreated only yesterday."

There are three lines of botanical evidence which appear to me to disprove a recent glacial epoch, as distinct from merely increased glaciation due to elevation in the central regions. They are—(1) the occurrence in the South Island and in the antarctic islands lying to the south of a remarkably specialised group of genera and species, some of which range into or are allied to forms occurring in Australia and elsewhere, but not found in the North Island; (II) the absence of deciduous-leaved plants in New Zealand; and (III) the occurrence of a xerophytic or desert flora. All these conditions demand an amount of time for their evolution much in excess of that granted by any theory of Pleistocene glaciation.

I.

According to Cheeseman's Flora, there are 332 genera and 1,415 species of flowering-plants in New Zealand. Of this number, two genera and forty-five species are peculiar to the antarctic islands (Macquarie, Campbell, Auckland, Antipodes Islands, and the Snares); while twenty-six genera and 452 species are found in the South Island which do not occur in the North Island.

If we take the genera in detail, we find the two genera peculiar to the antarctic islands to be more or less allied to others in the South Island. Thus *Stilbocarpa* (*Araliaceæ*), found in most of the islands. is allied to and probably derived from *Aralia*, a genus found in the Snares and Stewart Island, and in the south-west corner of the South Island. Of the three species of *Pleurophyllum*, *P. speciosum* and *P. criniferum* occur in the Auckland and Campbell Islands, while *P. Hookeri* is also found in these groups and in Macquarie Island. The genus is closely allied to *Celmisia*. "from which it is separated rather by the very distinct and peculiar habit than by any structural characters of importance."

But when we examine the genera (nine of which are peculiar) found in the South Island and not in the North, we meet with such diversity of structure and form that we are compelled to postulate long periods of time to account for their great differentiation, or else our views of evolutionary development are all wrong.

Among the *Cruciferæ* the genus *Pachycladon*, represented by one species found only in the mountain regions of Central and West Otago, is quite distinct from all other forms in New Zealand, and, indeed, is somewhat peculiar in its characters, being "intermediate between the tribes *Sisymbrieæ* and *Lepidineæ*." Another remarkable genus—*Notothlaspi*—has two species singularly developed to resist drought. This genus also is quite unlike any other. The genus *Hectorella* is not closely allied to any other genus of the order *Portulaceæ*, to which it belongs. *Corallospartium crassicaule*, the only representative of a remarkable genus of *Leguminosæ*, is allied to *Carmichaelia*, itself a genus peculiar to New Zealand (and Lord Howe Island). Another peculiar type of this order is *Notospartium*, which, though externally like *Carmichaelia*, differs in various points, such as its many-jointed pod, a sort of character which does not probably arise by gradual development from some other type.

Among *Compositæ* the only genus confined to the South Island is *Haastia*, a most remarkable group of four species of woolly-leaved plants. Here we have not only a distinct genus, but four distinct species developed since the separation of the Islands.

Tetrachondra is a genus of one species (*T. Hamiltoni*), which has hitherto only been found in the east and south of Otago. It is so anomalous in its characters that systematists are not even agreed as to its position. Kirk placed it in the genus *Tillæa* (nat. ord. *Crassulaceæ*); Oliver transferred it to the *Boragineæ*, among which Cheeseman also places it; while Hallier suggests that it should be considered an anomalous member of the *Scrophulariaceæ*, and that its nearest ally is the section *Pygmaea* of *Veronica*.

Anagosperma is a monotypic genus of the *Scrophularineæ*, allied to but distinct from *Euphrasia*. (*Siphonidium* of Armstrong is probably the same, according to Cheeseman.) Lastly, *Townsonia* is a monotypic orchid which has hitherto been found only in Nelson and Westland.

Making all allowance for differences of opinion as to what constitutes a generic distinction, yet the mere occurrence of such a group of specialised forms as these nine genera represent in the South Island of New Zealand alone surely implies a fairly long ancestry, and it seems quite unlikely that all these plants have spread from the North Island since its separation (if this took place in Pleistocene times), and have had time to differentiate so widely from other types.

But, leaving generic forms which are new, we find even more striking evidence of specific distinctions which are highly interesting.

(1.) There exist in the antarctic islands two species which occur in other parts of the world but not in the islands to the immediate north. If these islands were buried under an ice-sheet, all the vegetation must have been destroyed. In what way, then, could these plants have got to their present habitats within very recent times? They are *Azorella Selago*, found in Macquarie Island, and also in Kerguelen, the Crozets, Marion and Heard Islands, and Fuegia; and *Cotula plumosa*, found in all the antarctic islands, and also in Kerguelen and the Crozets.

(2.) Among South Island species not found in the North Island, a number occur whose allies are found in other parts. I have specified twenty-four species, as follows: *Swainsonia novæ-zealandiæ*, the only species in New Zealand, but belonging to a genus common in Australia; *Aralia Lyallii*, also unique, but allied to species in America and in the Northern Hemisphere; *Actinotus novæ-zealandiæ*, with a distribution similar to *Swainsonia*; *Crepis novæ-zealandiæ*, an anomalous form, most of the other species of the genus occurring in the Northern Hemisphere; *Isotoma fluviatilis*, similar to *Swainsonia*; *Pernettya nana*, a heath almost identical with a Tasmanian species, while all the other species are American; *Scutellaria novæ-zealandiæ*, with distribution similar to the last; *Exocarpus Bidwillii*, *Poranthera microphylla*, *Lyperanthus antarcticus*, *Iphigenia novæ-zealandiæ* — all four with immediate allies in Australia and other regions; *Triglochin palustre*, also found in South America and in the Northern Hemisphere; *Centrolepis strigosa*, also in Australia and Tasmania; *Gaimardia setacea*, whose nearest allies are in Tasmania and South America; *Uncinia Sinclairii*, also found in Fuegia; *Uncinia tenella*, also found in Australia; *Carex appressa*, *C. lagopina*, *C. trifida*, and *C. flava*, and four grasses (*Stipa setacea*, *Agrostis magellanica*, *Trisetum subspicatum*, and *Koeleria Kurtzii*), all with widespread distribution.

(3.) In addition to those species which have their nearest relations in other parts of the globe, or are themselves more or less widely distributed, there is a remarkable assemblage of species peculiar to the South Island or the more southern islands, and which do not range into the North Island. I need not give a full list of these, but must specify the most remarkable in order to show how greatly they are differentiated. They include *Ranunculus Lyallii* and *R. Buchanani*, with large white flowers, and the former with great peltate leaves; *Acæna glabra*, which has lost the spines and barbs on the calyx so characteristic of the genus; *Olearia insignis*, which differs from other species of the genus "in the large broadly ovoid involucre with the bracts in very many series, and in the pappus of perfectly equal hairs"; the singular group of large-flowered *Olearias*, which includes

O. operina, *O. angustifolia*, *O. Traillii*, *O. Colensoi*, and *O. Lyallii*; *Olearia fragrantissima*, with its heads collected into aggregate or compound heads; no less than thirty-four species of *Celmisia*, showing a great degree of modification; the remarkable *Raoulias* of the "vegetable sheep" type (*R. eximia* and *R. mammillaris*); *Raoulia grandiflora*, a type differing from all the others of the genus; several highly differentiated species of *Senecio*, including the climbing *S. sciadophilus*, and *S. geminatus*, a form allied to certain genera found in Juan Fernandez, and so distinct that Hooker formerly placed it in a distinct genus, *Traversia*; *Phyllachne clavigera*, a most singular plant, allied to a Fuegian form; *Lobelia Roughii*, "a most distinct species, quite unlike any other" of the genus in its three-lipped corolla; *Mitrasacme novæ-zealandiæ* and *M. montana*, the latter either identical with or very nearly allied to a Tasmanian species, while the other species are mostly Australian or south Asiatic. Then we have the remarkable development of the genus *Veronica*, in which occur some curious groups of forms: (1) the "whip-cord" species—*V. Gillesiana*, *V. tetrasticha*, *V. quadrifaria*, *V. tumida*, *V. lycopodioides*, *V. Hectori*, *V. coarctata*, *V. salicornioides*, *V. Armstrongii*, *V. propinqua*, and *V. cupressoides*; (2) the three moss-like species *V. pulvinaris*, *V. Thomsoni*, and *V. ciliolata*, originally separated by Hooker as a separate genus *Pygmæa*; (3) the anomalous *V. loganioides*, a species quite distinct from any other of the genus, and whose relationships are somewhat obscure; and (4) the curious dried-up-looking forms *V. Cheesemanii* and *V. canescens*. Altogether, the *Veronicas* constitute a group of forms which have probably been long isolated to bring about the remarkable differentiation which they now exhibit.

I have gone minutely into these details, and drawn my facts from an analysis of Mr. Cheeseman's Manual, because it is important in such a connection to show as fully as possible the evidence on which I base my opposition to the idea of a recent glacial epoch in New Zealand.

II.

One of the effects of the recent glaciation of the Northern Hemisphere was to produce among the woody plants which followed the ice in its retreat northwards a deciduous-leaved character. Woody plants characteristic of a cold temperate region, and liable to meet with heavy snowfalls in the winter months, can only escape destruction by special adaptation to such conditions. The simplest way, apparently, is to become deciduous on the approach of the cold season. Now, if we compare the characters of the British and the New Zealand floras in this respect, we find an interesting dissimilarity, which perhaps is best shown by tabulating them as follows:—

		Per Cent. of the Whole.	New Zealand.	Per Cent. of the Whole.
Total number of species ..	1,223	..	1,415	..
Woody species	91	7·4	450	31·8
Evergreen trees and shrubs	26	28·5	398	88·3
Deciduous trees and shrubs	65	71·4	7 (partly)	1·5 (?)
Leafless, or nearly so ..	..	..	45	10·0

Here we find that the woody plants of Britain—a region glaciated within recent geological times—constitute only 7·1 per cent. of the whole flora. Of the ninety-one woody plants in Britain, excluding prostrate and creeping species, sixty-five, or 71·1 per cent., are quite deciduous. The remaining twenty-six species are evergreen, but their foliage is of such a character that they are not liable to take any damage from snow. I append a list of these forms,* from which it will be seen that some of them are small-leaved heaths and similar plants.

New Zealand has 1,415 species of plants, but 450 of these, or 31·8 per cent., are woody. Of this number, no less than 398, or 88·3 per cent., are evergreen; forty-five, or 10 per cent., are leafless or have only minute appressed leaves: while seven species, or less than 1·5 per cent., are more or less deciduous. These are *Gaya Lyallii*, which is deciduous only at high levels and in the south end of the South Island, but is evergreen in the valleys of Nelson and Westland; *Aristotelia racemosa*, *A. Colensoi*, and *A. fruticosa*, which are also deciduous only at high levels; *Coriaria thymifolia*, also tending to become deciduous at high levels; and *Fuchsia excorticata* and *F. Colensoi*, which are deciduous at least in the southern part of New Zealand. Thus in the whole of New Zealand there is no absolutely deciduous species: and this is, to my mind, a strong argument against recent glaciation.

III.

A characteristic feature of the flora of New Zealand is the presence of a large xerophytic element, a very considerable group of the plants being specialised to endure desert conditions.

All green-leaved plants are furnished with stomata for the breathing in and out of the gases which they feed on and eliminate, and for the transpiration of water-vapour. Plants growing in peaty moorlands, and such as grow on the sea-coast, even in climates where there is relatively considerable humidity, are frequently specially modified to resist overtranspiration, and these modifications take the form of archings of the upper surfaces of the leaves, thickening of the tissues, and diminution of the number of stomata on all their breathing-surfaces. Eliminating these locally modified plants, which are common to many regions of the globe, we find in New Zealand, and especially on the eastern side of the Alps, and the hills and plains lying to the east of the dividing-range, an assemblage of plants—approximately estimated by me at 220 species—which are peculiarly adapted to withstand drought. Their breathing-surfaces are more or less covered with hairs, sometimes produced in extraordinary profusion, or they have greatly thickened epidermis with deep-set stomata, or the upper surfaces which have no stomata arch over and thus tend to close the pores on the sheltered undersides. In many the leaves become modified (*e.g.*, many species of *Veronica*), so as to lie closely pressed against the stem, or the leaves are more or less completely aborted (*Discaria toumatou* and species of *Carmichaelia*), the breathing-pores in such cases being produced on the epidermis of the branches and stems.

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* *Berberis vulgaris*, *Ilex aquifolium*, *Euonymus europæus*, *Genista tinctoria*, *Ulex europæus*, *U. nanus*, *Cytisus scoparius*, *Hedera Helix*, *Vaccinium Myrtillus*, *Arbutus Unedo*, *Andromeda polifolia*, *Erica Tetralix*, *E. cinerea*, *E. ciliaris*, *E. vagans*, *E. mediterranea*, *Calluna vulgaris*, *Phyllodoce cærulea*, *Ligustrum vulgare*, *Daphne Laureola*, *D. Mezereum*, *Hippophæ rhamnoides*, *Viscum album*, *Pinus sylvestris*, *Juniperus communis*, *Taxus baccata*.

I have made a series of experiments to test the amount of transpiration undergone by different plants, and these show interesting results as far as they have gone; but as only a limited number of plants have been examined up to the present, and the whole series seems to be worth concluding, I will not give more than a single example to illustrate the facts.

The method adopted was to take a newly cut leafy twig of *Fuchsia excorticata* (as a control), weigh it, and hang it up in a dry place for a stated time. Twigs or branches of the other plants to be tested were treated in the same way and for the same period of time. The method is not a very accurate one as a test of transpiration, but it gives comparative results which are suggestive. It only shows the actual loss by evaporation, but gives no correct idea of the amount of water which the plants tested could abstract from a constant water-supply and give out to the atmosphere through their breathing-surfaces. Still, the following facts are interesting:—

In *Fuchsia excorticata* there are no stomata on the upper surface of the leaves, but as many as 228 per square millimetre on the underside. These are all placed on a nearly level surface, so that when much evaporation takes place the whole leaf tends to wilt and wither.

In *Veronica Hectori* (a xerophytic form) there are also no stomata on the upper or appressed side of the leaf, but on the lower (outer) side there are about 128 stomata per square millimetre. These are placed in somewhat deep pits, so that when much evaporation takes place the guard cells above them overarch and tend to close the orifice, and the leaves show no sign of wilting.

A small leafy branch of *Fuchsia excorticata* exposed to dry air for twenty-eight hours lost 66·41 per cent. of its weight; a branch of *Veronica Hectori* exposed for the same time to the same conditions lost only 8·33 per cent. of its weight. This illustration is typical of the whole series: some lose a greater and some a lesser proportion of their moisture; but in all these 220 species of plants the amount lost by transpiration is very small when compared with a thin-leaved plant like the *Fuchsia*.

The cause which has led to the development of this desert flora would appear to be the extremely dry conditions which prevail on the eastern side of the main range of the Alps. This is brought about by the moisture-laden winds which strike the range from the north-west losing their water as they are forced over the mountain barrier, and descend on the east side as dry, hot winds. The average rainfall along the western side of the Southern Alps probably everywhere exceeds 100 in.; on the eastern side it is in many districts less than 20 in. It is impossible to get exact records, for they have not been kept; but on the Ida Valley Station, in Central Otago, where rain-gauge records were kept for a few years, I am informed the rainfall was always under 15 in. per annum, and in some seasons fell as low as 10 in. This extreme dryness, coupled with the intense winter frosts, has caused the disappearance of nearly all plants except such as were able to withstand these severe conditions. The average height of the main range may be taken as 7,000 ft.: if the range were elevated another 5,000 ft. it would produce a still more severely desiccated region, in which only a xerophytic flora could survive, and it would also account for all the Otago lakes and West Coast Sounds, and all the glacial phenomena required to explain Professor Park's views. Only it was probably much further back than the Pleistocene.

Art. XLV.—*The Discovery of Moa-remains on Stewart Island.*

By Professor W. B. Benham, D.Sc., F.R.S., Otago University.

[*Read before the Otago Institute, 7th December, 1909.*]

Some time last year I was informed by Mr. F. W. Murdoch, of Half-moon Bay, that he had discovered the bones of a couple of moas, one larger than the other, in the sandhills at Mason Bay, on the west coast of Stewart Island; and recently he gave a more detailed account of the find to Dr. Cockayne and to myself, in letters, from which the following quotations are made.

The interest of Mr. Murdoch's discovery lies in the fact that this is the first occasion, so far as I have been able to ascertain, that actual evidence of the existence of moas on the island has been produced or recorded, though he states that he has known for some time of fragments of their bones lying about Maori middens.

He writes, "The two skeletons, or remains of skeletons, were lying close together, only a few yards apart, about 400 yards inland from the beach. The gizzard-stones of the larger bird were in evidence, scattered about, but I did not notice any with the small skeleton. Truth to tell, I had not much time at my disposal: it was getting well on towards evening, and I had nearly the whole of that beach to traverse to reach the hut, the bones being near the south end of the beach. Nearly all the bones of the larger bird were there, I should think, with the exception of one of the long leg-bones. The greater part of the skull was there: it I brought home, and a portion of the breast-bone. . . . I think that some old-time Maoris must have also found those bones, for near by were lying two flakes of stone—not worked stone, but just the ordinary long flakes they used as knives or saws. The missing bone was probably appropriated by them to fashion into fish-hooks and needles." He suggests that the two birds died at about the same time—they were not killed by the Maoris. "I really think they were mother and chick. The old bird died" [first] "and the young one died later of starvation."

Mr. Murdoch readily complied with my request to be allowed to make an examination of the bones which he had collected—viz., the femur, tibio-tarsus, tarso-metatarsus, the back of the cranium, and two terminal phalanges (or claw-bones). The leg-bones are in a good state of preservation, white and firm, through brittle at the ends; but the cranium is much weathered, and is less satisfactory for identification purposes.

Measurements of the bones, and a comparison with named specimens in this Museum, show that the Stewart Island bird is *Euryapteryx* (*Emeus*) *crassa*, Owen, a species fairly common on the South Island, and very closely allied to *E. ponderosa*, Hutton. Of the latter Hutton* writes (p. 638), "The leg-bones differ from those of *E. crassa* more in thickness than in length"; and the figures given below agree very closely with those given by him on page 650, *loc. cit.*, and on page 132, Trans. N.Z. Inst., xxiv. But, as he gives in one place the "girth" and in another the "width" of the bones at the middle of their length, I have given both measurements, so that a comparison is rendered more easy with his and with Hamilton's account* of an individual skeleton of *E. ponderosa.* In measuring the length of the tibio-tarsus, the total length, including the cnemial crest, is usually given; but, since this crest is apt to be broken or worn away, I may suggest, perhaps, that it would be better to measure the length from the hinder margin of the articular platform to the lower margin of the internal condyle.

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* Trans. N.Z. Inst., xxviii, 1895.

The skull differs from those of *E. crassa* in our collection in one or two features: the supra-occipital is more nearly horizontal, and when the skull is viewed from above the occipital condyle is visible, whereas in a corresponding view of our skulls it is hidden by the supra-occipital: this may, however, be an individual variation, and, anyhow, the incompleteness of the skull renders this character of less importance for identification than the results obtained from the study of the leg-bones.

Measurements.

	Inches.	Millimetres.
Femur,—		
Length	10·8	279
Width at mid-shaft	1·9	48
Girth at mid-shaft	6·1	152
Width at distal end	5	127
Tibio-tarsus,—		
Length†	20·15	225
Width at mid-shaft	1·9	48
Girth at mid-shaft	5·4	137
Width at distal end	3·5	89
Tarso-metatarsus,—		
Length	8·75	240
Width at mid-shaft	1·9	48
Girth at mid-shaft	5·2	132
Width at distal end	4·5	115
Cranium —		
Width at temporal fossa	2·05	52

The measurements were made by means of craniometrical callipers for width, and between vertical uprights for length.

Mr. Murdoch will, I hope, endeavour to obtain the bones of the smaller individual; but, as he remarks, it is very likely that this will be a difficult matter, for they may be concealed again by sand, which had fortunately been blown away by wind just before his previous visit, leaving the bones exposed; for he had often passed the spot before without seeing them. I await with much interest the opportunity to examine them, for they may belong to a young individual of the same species, as Mr. Murdoch believes—which will, of course, easily be confirmed by the state of the bones. Nevertheless, on other occasions when similar suggestions have been made with regard to two or more specimens of different sizes found lying near one another, careful examination has rudely dissipated the view, for they have been found to be the remains of adults of two different species.

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* Hamilton, Trans. N.Z. Inst., xxx, 1897, p. 445.

† These numbers are estimated; for a portion of the cnemial crest—probably about ¾ in. (15 mm.)—was broken off: this is allowed for in the above numbers. The length of tibio-tarsus from hinder edge of platform to lower end of internal condyle is 18·5 in.

Euryapteryx crassa is a moa of medium height, standing about five or six feet; heavy in build, with relatively short legs and broad pelvis. Its beak is short and stout, with a rounded tip. A restoration of an allied species, *Pachyornis elephantopus*, may be seen in the Dunedin Museum.

I have to thank Mr. Murdoch for so generously placing the bones at my disposal.

ART. XLVI.—*A Comparative Study of the Anatomy of Six New Zealand Species of* Lycopodium.

By J. E. HOLLOWAY, M.Sc.

[Read before the Manawatu Philosophical Society, 10th November, 1909.]

INTRODUCTION.

THE six following species, native in New Zealand, are considered in the present paper:—

(1.) *Lycopodium volubile*, Forst.
(2.) „ *scariosum*, Forst.
(3.) „ *densum*, Labill.
(4.) „ *laterale*, R. Br.
(5.) „ *cernuum*, Linn.
(6.) „ *Billardieri*, Spring.

A comparative account is here given of the early stages in the development of the young plants of all six species, and also of the development of the stelar anatomy of the mature plant. An account is added of the development of dimorphism in the leaf-arrangement of *L. volubile* and *L. scariosum*, and some other points of interest brought out during the course of the study are noticed.

This study was begun a number of years ago in the laboratory of the Auckland University College, under the guidance of Professor A. P. W. Thomas. The writer desires to record his grateful appreciation of this gentleman's kind interest and valued advice, as also of that of the Rev. G. B. Stephenson. To Mr. William C. Davies, of Greytown, his thanks are due for the excellent photomicrographs.

PROTHALLUS.

It has been considered to be beyond the scope of this present paper to give any detailed account of the prothalli found whilst the study was in progress. It is hoped that some such account will be given elsewhere. It will suffice here merely to indicate their more obvious external characteristics in order to show the nature of the dependence of the young plant upon its prothallus.

The prothallus of *L. cernuum* is well known. Young plants with prothalli attached were found in abundance in two localities, growing on damp clay banks. The prothallus grows at the surface of the ground, is very small, delicate, and short-lived. In the case of *L. laterale* prothallial plants were found in two localities, growing on recently overturned marshy soil. The prothallus of this species corresponds to the type of *L. cernuum,* and is small and short-lived, and situated at the surface of the ground. Prothalli of *L. Billardieri* were found growing in a collection of humus on a bush tree, young plants being collected from several such localities. The prothalli are destitute of chlorophyll, are much branched, and grow beneath the surface of the soil. They are long-lived; in some cases young plants an inch or more in height, and bearing three well-developed leaves, were observed with healthy prothalli still attached to them. The prothalli seen ranged from 1–12 mm. in total length. The prothallus of this species appears to correspond to the *L. phlegmaria* type. Prothallial plants of *L. volubile* were found in three distinct localities. The prothallus is large, firm, and long-lived. Healthy prothalli were seen still attached to plants which were as much as 10 cm. in length. Generally the prothalli are subterranean, being buried from 1 4 cm. in depth; in several instances, however, they were observed growing at the surface of the ground, and the upper portion of the prothallus was then well supplied with chlorophyll. The prothallus of *L. scariosum* was discovered in two localities. Like that of *L. volubile,* it appears to correspond to the *L. clavatum* type. It is large, firm, and long-lived, and in every case was found deeply buried (from 2-6 cm.). Long-continued search was made for the prothalli of *L. densum* in many localities, but without success. One young plant, however, was discovered, on which, as in the case of the young plants of *L. volubile* and *L. scariosum,* there was a large persisting "foot" situate at a point on the stem some distance below the surface of the ground. We may accordingly conclude that the prothallus of this species is large, firm, and long-lived.

EARLY EMBRYONIC STAGES.

No minute study of the prothalli of the above-mentioned species was made, so that the early embryonic stages of the young plants were not observed.

PROTOCORM.

The young plants of *L. cernuum* and *L. laterale* both possess this organ. This is so well known in the case of *L. cernuum* that it will not be necessary to give any detailed account of it here, so far as this species is concerned. The protocormous structure in the young plant of *L. laterale,* however, would seem to afford such interesting material for the discussion of the significance of this organ that an account of its development in this species will now be given. The first stages in the development of the protocorm of *L. laterale* correspond closely to what takes place in *L. cernuum.* The subsequent stages are, however, peculiar: Instead of a stem apex being differentiated at a comparatively early stage, as in *L. cernuum,* its development is postponed for a considerable time; and, instead, the protocorm grows greatly, and elongates sideways as a rhizomatous structure, bearing numerous protophylls along its dorsal surface (Plate XXXI, fig. 5). This "rhizome" is composed entirely of parenchymatous cells, in which starch and water are stored; numerous rhizoids arise from its ventral surface. The "rhizomes" shown in Plate XXXI, figs. 7 and 8, had attained a length of 1 cm. and a thickness of from 2-3 mm.; that shown in fig. 8 had branched. Eventually the protophylls aggregate at some point on the dorsal surface of the "rhizome," and a stem apex is differentiated. In the case of the young plant shown at Plate XXXI, fig. 8, where the rhizome had branched a stem had developed on each branch.

Whether (with Bower) we regard the protocorm as being a late specialisation—a "gouty interlude" in the development of the sporophyte from its strobiloid ancestor—or whether, on the other hand, we regard it as being the representative of a possible thalloid ancestor, the case of *L. laterale* is interesting as indicating the important degree of development of which this protocormous organ is capable. In the young plant of *L. cernuum* the protocorm is seen to function only as a very temporary organ, important only during the short period which intervenes between the stage at which the young sporophyte has begun to grow beyond the supply of food contained in its prothallus and the point of development of its own regular assimilatory system of stem leaves and root. In this species, although the stem axis and first root are not differentiated at a very early stage, they, at any rate, make their appearance very much earlier than in the case of *L. laterale*. In this latter species the protocormous "rhizome" attains a considerable size, and constitutes the plant body for a long period, and by no means bears the character of a mere temporary organ. The stem and first root are here very late in development. It might seem at first sight that the case of *L. laterale* affords an argument against the theory of the late phylogenetic development of the "protocorm," favouring rather that other theory which would regard it as the very much reduced representative of a thalloid body, the homologue of the "prothallus." It must, however, be borne in mind that with considerable reason it may be urged that the protocormous rhizome of *L. laterale* is merely a physiological specialisation peculiar to this species, designed to carry the young plant over a season unsuitable for its further development. In this connection we observe that the usual habitat of *L. laterale* is a marshy one, and that the rhizome is stored with starch and water.

In the examination of the young plants of the remaining four species, no structure comparable to the protocorm was found.

FOOT.

A series of longitudinal microtome sections of the young plant of *L. cernuum*, shown at Plate XXXI, fig. 1, was taken, and this revealed the fact that the "foot" was exceedingly small.

In the case of *L. volubile*, *L. scariosum*, *L. densum*, and *L. Billardieri* the foot was always large and very persistent, being recognisable on the young plant long after the prothallus had decayed away. In *L. cernuum* it consisted of a very few similar parenchymatous cells; but in the latter four species the layer of cells of the foot adjacent to the prothallial tissues was developed as a distinct epithelial layer (see Plate XXXI, fig. 17), whilst the more centrally placed cells were elongated slightly in the direction in which food substances would pass from the prothallus into the vascular strand of the young plant. The vascular tissues of the stem in these species did not enter the foot, but passed directly into the root.

FIRST ROOT.

In the young plants of *L. cernuum*, about the same time as the stem apex is differentiated, the first root makes its appearance as a superficial outgrowth of the upper region of the protocorm (Plate XXXI, fig. 2), into which the vascular tissues of the stem later pass bodily. A longitudinal section of the young plant at such a stage as that shown at Plate XXXI, fig. 2, shows that the first root originates as an irregular extension of the tissues of the protocorm. In the case of *L. laterale*, the first root arises very late, as a superficial outgrowth of the protocormous "rhizome," at one of its ends (Plate XXXI, fig. 7). As the vascular tissues of the stem develop they pass down bodily into the rhizome, and, surrounded by a zone of sclerenchyma, make their way through it immediately beneath its dorsal surface into the root-like protuberance. A longitudinal section of the plant figured at Plate XXXI, fig. 7, showed the tissues of the rhizome continuous with those of the root. In each of the species *L. Billardieri*, *L. volubile*, and *L. scariosum* prothallial plants were observed in which the first root had just made its appearance as a conical outgrowth at the base of the stem, directed outwards and downwards (Plate XXXI, figs. 10, 17). In these species the root is not differentiated till the apex of the stem has reached the surface of the soil and assimilatory leaves have begun to develop. Longitudinal sections of the young plants of *L. volubile* and *L. Billardieri* (figured at Plate XXXI, figs. 10 and 17 respectively) showed that in each case the vascular tissues of the stem passed directly down the root, and did not enter the foot.

The question of the origin of the first root is suggested by the study of the development of the first root in *L. cernuum* and *L. laterale*. In his book on "The Origin of a Land Flora" Bower says, "The origin of the root may be held to have been accessory in evolution, as it is seen to be late and variable in individual development." This view does seem to be in accordance with what has been noted above. The idea suggests itself from the study of *L. cernuum* and *L. laterale* that one way in which the origin of the root may have come about was from the irregular growth and branching of the protocorm. In both these species the protocorm, by means of its rhizoids, acts as a root for a longer or shorter period; and in the case of *L. laterale* the protocorm grows irregularly to a considerable extent, and may even branch. Also, in both species the early stages in the development of the first root are in no way different from the further irregular extension of the tissues of the protocorm in the form of a protuberance. In the case of *L. Billardieri*, *L. volubile*, and *L. scariosum* the very late appearance of the root is probably to be put in connection with the increased dependence of the young plant upon its prothallus for food-supplies.

PROTOPHYLLS.

In both *L. cernuum* and *L. laterale*, before the stem axis, with its regular leaf system, is differentiated, the work of assimilation is performed partly by the protocorm (which is well provided with chlorophyll), but especially by certain leafy extensions of the protocorm, to which the term "protophylls" has been applied. These protophylls bear numerous stomata, and in longitudinal section show a vascular strand leading down into the protocorm. They are few in number in the case of the young plant of *L. cernuum*, not more than five or six being formed before the stem axis is differentiated (Plate XXXI, figs. 2, 3); but in the young plants of *L. laterale*, where the protocormous stage is a lengthy one, they are much more numerous.

There is no sudden change in the passage from protophylls to stem leaves; in fact, in these two species the regular foliage leaves are not very much different in form from the simpler protophylls.

In the case of the young plants of *L. Billardieri*, *L. volubile*, and *L. scariosum* there is no trace of protocorm, nor of protophylls.

DEVELOPMENT OF STEM AND LEAVES.

In the early stages of the young plant of *L. cernuum* the main axis of the plant cannot be designated a stem, for it consists merely of the persisting protocorm surmounted by the fused bases of the protophylls; but, after five or six protophylls have been formed, they are seen to aggregate at a point on the upper extremity of the protocorm, and a definite stem apex becomes differentiated there (Plate XXXI, fig. 3). The development of the stem is very late in *L. laterale*, but when this does take place it is initiated by the aggregation of the protophylls at some particular point or points (Plate XXXI, figs. 6–8).

In the case of *L. Billardieri*, *L. volubile*, and *L. scariosum* the earliest stages in development of stem were not observed; but a comparatively early stage was that when the stem axis showed as a simple, slender, cylindrical stem, bearing only a few scattered minute scale leaves (Plate XXXI, fig. 10).

The regular foliage leaves of *L. cernuum* and *L. laterale* develop immediately upon the stem apex being differentiated.

The stem axis of the young plants of *L. Billardieri*, *L. volubile*, and *L. scariosum* remains destitute of leaves till the apex has reached the surface of the ground. In the case of *L. Billardieri*, the young stem was observed thus leafless for 1–6 cm. in height, in *L. volubile* for 1–4 cm., and in *L. scariosum* for 1–10 cm.

A few chlorophylless scale-like leaves are very often to be seen on that part of the stem which is underground. As soon as the stem apex has risen above the surface of the ground the usual assimilatory leaves are immediately developed, those of *L. Billardieri* being broad and large compared with the size of the plant, whilst those of *L. volubile* and *L. scariosum* are small and needle-like.

The foot of the single young plant of *L. densum* found was situated about 4 cm. below the surface of the ground. The stem for this length was leafless, and above the leaves were of the usual acicular form.

GENERAL REMARKS ABOUT THE YOUNG PLANTS OF LYCOPODIUM.

In his paper on "The Prothallus of *L. clavatum*,"* Lang, starting from the assumption that "in the *L. cernuum* type the primitive form of prothallus and young plant has been most completely retained," suggested that from this type other forms have been derived "in which the gametophyte is adapted to the saprophytic mode of life." He suggested that the various species of *Lycopodium* so far studied could be arranged in a series illustrative of the gradual reduction of protocorm and development of the foot consequent on the increasing dependence of the young plant upon its prothallus.

There is nothing arising from this present study to be brought forward in contradiction to this suggestion. The important development of the protocormous organ in the young plant of *L. laterale* may be considered either as a later specialisation of the type of protocorm seen in *L. cernuum* or as representing an earlier stage in the history of the organ. *L. Billardieri*,

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* Ann. of Bot., June, 1899.

L. volubile, *L. scariosum*, and probably, too, *L. densum*, may be taken as corresponding to the type of *L. clavatum* in the mode of dependence of the young plant upon its prothallus.

EARLY STAGES IN DEVELOPMENT OF VASCULAR SYSTEM.

The earliest stages were traced in the case of *L. cernuum* and *L. laterale*. A few spiral tracheids and phloem elements become differentiated at the base of each protophyll. These elements extend downwards into the region of the protocorm, where they end blindly.

The vascular system of the stem axis originates from the leaf-traces which aggregate loosely and indefinitely at the centre of the stem. Later, when a plerome cylinder develops, the leaf-traces affix themselves to its periphery. Transverse sections of stems of young plants of these species at this stage show that there is no definite arrangement of the vascular tissues, the different xylem and phloem elements preserving no constant relative positions. The vascular tissues of the stem lead down bodily into the upper region of the protocorm, and, surrounded by a slight zone of sclerenchyma, enter the root-like protuberance, in the case of *L. laterale* passing along the dorsal surface of the protocorm immediately beneath the epidermis. In the young plant of both these species the leaves are very numerous and irregularly arranged. The leaf-traces attach themselves indiscriminately to the periphery of the plerome cylinder, forming later an almost continuous ring around the central vascular tissues.

In the three species *L. Billardieri*, *L. volubile*, and *L. scariosum* the stems of the youngest prothallial plants sectioned were from ½–1 cm. in height, being simple, erect, cylindrical, and apparently destitute even of scale leaves. In these species vascular tissues are developed as a plerome cylinder in the stem of the young plant before either leaves or first root appear, and function probably in transferring food material from the prothallus to the growing regions of the stem. In the young stem of *L. Billardieri* the first stage in the development of the stele shows a single compact somewhat crescentic-shaped group of protoxylem enclosing a single group of protophloem. In both *L. volubile* and *L. scariosum* the stem stele from the very first is compact, and the arrangement of its tissues definite; in *L. volubile* it at first shows two protoxylem groups, between which is a single group of protophloem. Plate XXXII, fig. 2, is a drawing of the stele of a young plant 1 cm. high and destitute of leaves. In *L. scariosum* from the first the stele is of larger size, and the protoxylem and protophloem more strongly developed than in the young plant of *L. volubile*. The first stages show from 3–5 protoxylem groups. Plate XXXII, fig. 3, shows the stele of a young plant 1½ cm. high, and destitute of leaves. The very early stages in the development of the stem stele of *L. densum* were not observed, but they will probably be found to correspond closely to those of the two last named species, since in other ways the young plant of *L. densum* corresponds closely to the type of *L. volubile* and *L. scariosum*.

It will thus be seen that two distinct types of arrangement of the vascular tissues in the very young stem are shown by the study of the above six species—namely, the loose indefinite type of *L. cernuum* and *L. laterale* and the more compact definite type of *L. Billardieri*, *L. volubile*, and *L. scariosum*. These two types of stelar arrangement would seem to be, to some extent at least, correlated with the two types of leaf-trace system shown in the young plants of these species. In *L. cernuum* and *L. laterale* the leaf-traces are very numerous and irregularly disposed, and their loose aggregation at the centre of the stem axis is prior to the development of a regular plerome cylinder; moreover, after the development of the plerome cylinder, the leaf-traces attach themselves quite indiscriminately to any point on its periphery. In the young plant of *L. Billardieri*, *L. volubile*, and *L. scariosum*, however, the development of the leaf-trace system is much subsequent to that of the regular plerome cylinder, and the leaf-traces attach themselves very definitely to the compact protoxylem groups of the cylinder. In these latter species also the leaf-traces are far less numerous than in the two former species; especially is this so in the young plant of *L. Billardieri*, where the leaves are few in number, arranged in two and three orthostichies, and are very large and broad compared with the size of the plant. We may thus regard the type of vascular arrangement in the young plant of *L. cernuum* and *L. laterale* as being less specialised than that in *L. Billardieri*, *L. volubile*, and *L. scariosum*, and representing an earlier stage in the development of the *Lycopodium* stele, the more definite arrangement as shown in the three latter species being made possible by the diminution in number of the leaf-traces consequent on the adoption by the prothallus and young plant of subterranean habits.

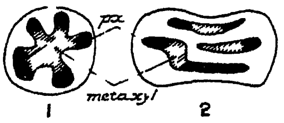
DEVELOPMENT IN COMPLEXITY OF STEM STELE.

The development in complexity of the loose or "mixed" type of stem stele of *L. cernuum* and *L. laterale* shows no features worthy of special note. Throughout the life of the plant of both species the vascular tissues of the stele show a very indefinite conformation, the phloem and xylem elements being loosely grouped together in irregular bands and islands whose forms are constantly changing. The numerous leaf-traces attach themselves indiscriminately to the periphery of the stele. There is no rearrangement of the stelar tissues preparatory to branching. In the smaller branches there is no definite radial arrangement of the vascular tissues, and no constant relation to be observed subsisting between the leaf-trace system and the number of protoxylem groups. In the strobili of *L. laterale*, however, where the leaves are arranged in six orthostichies in alternate whorls of three, the arrangement of vascular tissues is consistently and definitely triarch, and there is a constant relation between the leaf-trace system and the number of protoxylem groups.

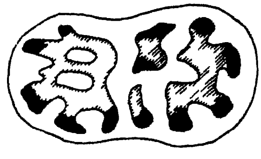
The development in complexity of the definite compact type of stem stele of *L. Billardieri*, *L. volubile*, and *L. scariosum* was closely followed, abundant material being to hand for the purpose. In the case of *L. volubile* and *L. scariosum*, features were noticed which may possibly throw some light on the well-known "parallel" or "dorsi-ventral" arrangement of vascular tissues of which these two species are such excellent examples.

In *L. Billardieri*, in plants about 2 in. high, showing from 10–12 well-formed leaves, the stem stele consists of two compact xylem groups and a single intermediate phloem group. The number of xylem groups later becomes three by the splitting of one of the two original groups, and the phloem extends between these groups. The disposition of vascular tissues in the stem is definite throughout the life of the plant, the individual elements of xylem and of phloem being mutually coherent.

Branching of the stem is dichotomous; it is not restricted to one plane. In the main stem there is no particular rearrangement of the xylem and phloem plates preparatory to branching. In the smaller branches the plates of tissue very often arrange themselves more or less at right angles to the plane of division (see accompanying diagrams 1-3); but this "parallel" arrangement becomes immediately lost in the daughter branches. In the terminal branchlets the number of orthostichies of leaves may be from 1–6 and the number of protoxylem groups in the stele from 3–6, there



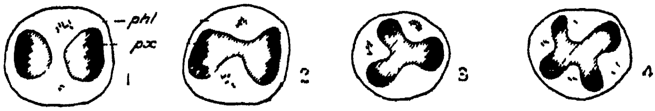
FORKING OF STELE IN BRANCHLET OF L. BILLARDIERI.



FORKING OF STELE IN MATURE STEM OF L. BILLARDIERI.

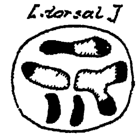
being no constant relation between the number of orthostichies and the number of protoxylem groups. The strobili are tetragonous, the leaves being borne in opposite pairs; the number of protoxylem groups in the strobili is generally three.

In *L. volubile*, as the young plant grows the two xylem groups join across, thus separating the phloem into two groups. Next, the stele loses its diarch form, and becomes triarch through the splitting of one of the extremities of the xylem plate. The arrangement is now radial, three xylem plates alternating with three phloem groups. Then, through further splitting the arrangement becomes successively tetrarch and pentarch.



DEVELOPMENT OF STELE IN YOUNG PLANT OF L. VOLUBILE.

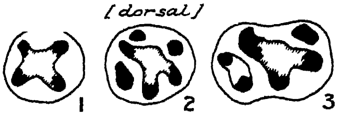
The individual elements of the xylem are mutually coherent in compact and definite plates radiating from the centre, and the phloem is in groups. This compactness and definiteness in the grouping of the xylem and phloem tissues is a characteristic feature right through the life of the plant. When the pentarch stage is reached, the plates of tissue do not preserve a constant disposition, but are constantly joining up with each other and separating again, presenting various forms of arrangement; moreover, two protoxylem groups may fuse into one, the pentarch thus passing back again into the tetrarch or even into the triarch. This inability of the plates of tissue to preserve strictly constant positions is seen also in the mature stem, although there to a much less degree owing to the parallel arrangement.



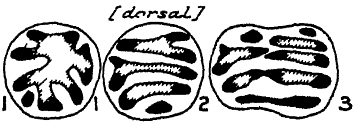
FORKING OF STELE IN YOUNG PLANT OF L. VOLUBILE.

Considerable attention was given to tracing the development of the "parallel" arrangement of the bands of xylem and phloem in the stele of the main stem of *L. volubile*. Now branching of the stem is frequent, and is always in the plane of the ground. In the young plant, as has been seen, the vascular tissues of the main stem show a radial arrangement, which, however, is constantly changing in conformation. It was found that at the point of branching of the main stem there is frequently a decided rearrangement of the bands of tissue in a direction at right angles to the plane of division. In young plants this "parallel" disposition of the bands becomes immediately lost in the resultant branches, but in plants of increasingly greater size it tends to be preserved.

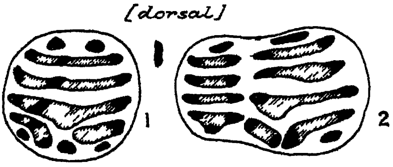
Series of sections at the point of branching were cut in a large number of plants of various stages of growth, and the general result arrived at was as follows: (1.) In young plants where the number of protoxylem groups in the stele is not more than five there is no "parallel" rearrangement of the bands preparatory to branching, but the protoxylem groups increase in number by splitting. In the case figured the stem had four protoxylem groups, and the resultant branches four and three respectively. (2.) In plants where the protoxylem groups number from six to nine there is very frequently, though not always, a marked disposition of the bands more or less parallel to one another, the plane of this disposition always being at right angles to the plane of division. In some cases, quite irrespective of branching, owing to the constantly changing disposition of the bands of tissue in between successive branchings, the stele may, apparently by accident, come to show quite a parallel arrangement, which, however, soon becomes lost again. (3.) In still older plants, where the number of protoxylem groups is more than nine, a more or less parallel arrangement is generally to be found in between the branchings. In the mature plant, where the number of protoxylem groups is from ten to sixteen, the parallel arrangement is very marked (Plate XXXIII, fig. 3). The arrangement of the bands on the ventral side of the stele is broken up by the giving-off of the adventitious roots.



FORKING OF STELE IN A YOUNG PLANT OF L. VOLUBILE. (CASE 1.)



FORKING OF STELE IN OLDER PLANT OF L. VOLUBILE. (CASE 2.)

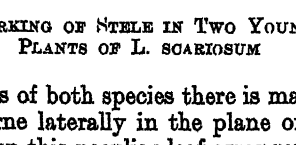


FORKING OF STELE IN MATURE PLANT OF L. VOLUBILE. (CASE 3.)

In *L. scariosum*, as in the case of *L. volubile*, considerable attention was given to the study of the development of the parallel arrangement of the stelar bands in the growing plant, and the same general conclusion was arrived at—namely, that generally, though not always, the parallel arrangement makes its first marked appearance in connection with the branchings.

Branching is frequent and always in the plane of the ground, and as in *L. volubile* the stelar plates are always disposed at right angles to the plane of division.

In the smaller branches of both *L. volubile* and *L. scariosum* the parallel arrangement is found in the older parts, but becomes lost as the stele decreases in size. In the ultimate branchlets of both species there is marked heterophylly, and the larger leaves are borne laterally in the plane of the ground. There is no correspondence between this peculiar leaf-arrangement and the stelar arrangement, the latter generally being tetrarch and radial;



FORKING OF STELE IN TWO YOUNG PLANTS OF L. SCARIOSUM nor is there any such correspondence to be traced in the strobili. In the large adventitious root, where the number of groups is from ten to fifteen, the vascular arrangement is always radial.

The development of stelar structure in *L. densum* was not traced in detail, only one young plant being found. In this plant the stelar arrangement was hexarch and radial, and there was no special rearrangement of stelar tissues to be traced preparatory to branching. In the older stem of *L. densum* the division of the stem stele preparatory to branching is always at right angles to the plates of tissue. The aerial branches are often of strong growth, and then the stele is stout; in one case, in the oldest part of the branch, the stele showed twenty-one protoxylem groups. In the oldest parts of the branches the arrangement is generally "parallel," persisting from the arrangement of the tissues at the branching of the main stem. Higher up in the aerial branches the parallel gives place to a radial arrangement. The many branchings of these aerial shoots are not restricted to one plane. The arrangement of stelar tissues throughout the aerial branches is very inconstant, and is in the older parts constantly passing backwards and forwards from the parallel form to the radial. In the ultimate branchlets there was no correspondence to be found between the number of orthostichies of leaves and the arrangement of stelar tissues.

THE MATURE STELE.

Plates XXXIII and XXXIV are photomicrographs of the mature steles of each of the six species considered in this present study. Of these six species, the steles of all except *L. laterale* (Plate XXXIII, fig. 1) are of exceptionally large size, and consequently most satisfactory to study as types. Seeing that it is a characteristic feature of the genus *Lycopodium* that there are to a greater or less extent continual changes going on in the conformation of the stelar tissues, it will be seen that the larger the stele the more satisfactory the example will it be of the particular type of arrangement that it shows. *L. cernuum* is well known as showing typically the mixed arrangement (Plate XXXIII, fig. 2); *L. Billardieri* is a good example of the radial type (Plate XXXIV, fig. 3), the mature stele showing from nine to fourteen protoxylem groups; *L. volubile* (Plate XXXIII, fig. 3), *L. scariosum* (Plate XXXIV, fig. 1), and *L. densum* (Plate XXXIV, fig. 2) rank as three of the largest of modern *Lycopodiums*, the number of protoxylem groups in the mature stele being—for *L. volubile*, 10–15; for *L. scariosum*, 18–27; and for *L. densum*, 15–20. These three latter species show typically the parallel type.

Plate XXXII, figs. 1, 4, show clearly the difference between the mixed and the parallel arrangements, both in the manner of disposition of the protoxylem elements and also in the grouping and mutual coherency of the metaxylem elements.

It is interesting to note that in the case of *L. cernuum* and *L. laterale* the cortical tissues remain for the most part soft and parenchymatous throughout the life of the plant. In *L. Billardieri* the outer region of the cortex, and in *L. volubile*, *L. scariosum*, and *L. densum* from the very early stage in the development of the plant, almost the whole of the cortical tissue becomes sclerenchymatous. This enveloping zone of hard tissue would no doubt tend to impart a certain degree of rigidity to the developing stelar tissues, and may possibly bear some relation to the definite stelar arrangement characteristic of these species.

DEVELOPMENT OF HETEROPHYLLY IN L. VOLUBILE AND L. SCARIOSUM.

(1.) *L. volubile.*

(*a.*) In no case was heterophylly to be seen in plants under 6 cm. or 8 cm. in length. In such plants the leaves are of the usual acicular form, arranged in an irregular spiral. (*b.*) In slightly older plants a change becomes apparent in the disposition of the leaves on the third or fourth branch, a tendency to dorsi-ventrality being shown in the fact that the two orthostichies on each lateral face of the branch are approximating to one by being slightly flattened in the plane of the ground, the leaves, however, still showing the usual acicular form. (*c.*) Later branches show a still more marked dorsi-ventral arrangement; there are still seven or eight orthostichies; on each lateral face of the branch there are two orthostichies approximated to such an extent that they almost have the appearance of being one; moreover, these laterally borne leaves have developed somewhat extended wing-like bases in the plane of the ground. On the ventral surface of the branch there are two orthostichies, the leaves of which are of the usual size and form. On the dorsal surface there are also two orthostichies of leaves of the usual form, but slightly reduced in size. (*d.*) On still older branches the dorsally and ventrally borne leaves are very much reduced in size, and are closely adherent to the stem, and are directed forward towards the apex of the branches (Plate XXXI, fig. 13*a*). The laterally borne leaves have assumed the marked dorsi-ventrality so characteristic in the mature plant, but the origin of the lateral orthostichy from the approximation of two can still be traced in the fact that its individual leaves point alternately slightly upwards and downwards. There are one or two orthostichies of scale-like leaves on the ventral side, and from one to three on the dorsal side.

Very often a young plant bearing six to ten branches will show every stage in the change from the spiral to the distichous arrangement and from homophylly to heterophylly.

(2.) *L. scariosum.*

In this species the heterophylly is developed at a very much earlier stage than in *L. volubile* (Plate XXXI, fig. 14), before the young plant has lost its erect habit. At first the leaves are acicular in form, and are borne spirally, although the number of orthostichies is less than in *L. volubile*, and the leaves are coarser. The change to heterophylly and dorsi-ventrality is very rapid. The leaves in the two orthostichies of what afterwards becomes the dorsal side of the stem first increase in length, then become very much flattened and extend on either side of the midrib, and finally bend over into a lateral position on either side of the stem. The dorsal origin of these large laterally borne leaves is apparent throughout the life of the plant (Plate XXXI, fig. 15*a*). The leaves which were originally borne laterally become pushed into a ventral position; in slightly older plants the ventrally borne leaves gradually become reduced to mere scales. They are borne in regular orthostichies from two to four in number (Plate XXXI, fig. 15*b*).

From the above account it will be seen that although in *L. volubile* and *L. scariosum* there is at first sight a striking similarity in the heterophylly and in the dorsi-ventral arrangement of the leaves, yet the development of this has been different in the two species.

Additional Points of Interest noted in the Course of this Study.

Stem-apex.—Plate XXXII, fig. 7, shows the apex of a terminal branchlet of *L. densum* in longitudinal section; Plate XXXII, fig. 8, the apex of a young strobilus of *L. volubile*.

Branching of the Stem.—Stem-branching is dichotomous in the genus *Lycopodium*. Three consecutive sections are figured at Plate XXXII, figs. 9 11, of a very early stage in the dichotomous branching of the stem of *L. volubile*. The sections, unfortunately, were not taken quite in the plane of branching, but their general outline shows sufficiently clearly that a true dichotomy has taken place.

Mucilage.—*L. volubile* is a scrambler, and its adventitious roots are often to be seen growing to the length of 2–5 ft. before they reach the ground. During the wet season, in the latter part of the winter, the season of the greatest growth, when these roots are growing very fast, a very characteristic feature to be observed is the large thick coating of mucilage which envelopes from 3–12 in. in length of the growing root-tip. Mucilage is also to be found on the adventitious roots of *L. scariosum* and *L. cernuum*, though in these species it occurs to a much less extent, owing to the fact that the stems grow close to the ground, and the adventitious roots are consequently short.

Possibly this mucilage functions as a protection for the growing root, keeping its delicate tissues moist till it reaches the ground. This mucilage after a period of dry weather shows only as a dry membranous skin, and if the dry weather persists the root-tip withers.

Root-apex.—Plate XXXII, fig. 5, shows a longitudinal section of the apex of an adventitious root of *L. volubile*. Plate XXXII, fig. 6, shows a region of the piliferous layer of the same root behind the apex, with the mother cells of the hairs cut off from the epidermal cells.

Conclusion.

I. *Classification of the Six Species.*

The study of the arrangement of stelar tissues in the above six species of *Lycopodium* seems to indicate that there are two distinct types under which they should be classified— viz., the "mixed" type and the "definite" or "banded" type; the banded type to be further subdivided into the "radially" banded and the "parallel" banded. It will be best to clearly define these terms as here used. The term "mixed" signifies the indiscriminate indefinite arrangement of the xylem and phloem in the stele, the loose way in which the xylem elements especially cohere together into groups and bands, the way in which the phloem is indiscriminately scattered between the various xylem groups, the spreading-out of the protoxylem around the periphery of the stele. The term "banded" signifies the steady coherency of the xylem elements into bands or plates of tissue, and the aggregation of the protoxylem into compact groups at the extremities of these bands at the periphery of the stele. The term "radially" banded is applied to that arrangement of these bands or plates in which they are seen to radiate from the centre of the stele like the spokes of a wheel. This radial type is seen best in the young plants of many species and in the small branchlets of mature plants, where the plates are from three to five in number. The term "parallel" banded is applied to that arrangement of the bands in which they are disposed more or less parallel to each other, separated by bands of phloem, the tendency for neighbouring plates to join up with each other being for the most part absent.

The classification of the six species considered in this study will then be as follows: (1.) Mixed—*L. cernuum*, *L. laterale*. (2.) Banded—(*a*) Radial *L. Billardieri*; (*b*) parallel—*L. volubile*, *L. scariosum*, *L. densum*.

It will be borne in mind that in those steles that conform to the parallel type the parallel disposition of the bands will be found only on the dorsal side of the stele, the arrangement on the ventral side being radial on account of the frequent giving-off of the adventitious roots.

II. *The Relation between the "Radial" and the "Parallel" Type.*

In studying the development of the stem-anatomy of *L. volubile* and *L. scariosum* it was seen how easily the radial arrangement can pass into the parallel, and *vice versâ*. This is noticeable more particularly in the earlier stages of development, when the protoxylem groups are from five to nine in number. In young plants which have just got beyond the strictly radial stage of triarch and tetrarch, the parallel arrangement may be attained as a mere temporary phase in the course of the various changes in stelar conformation that are continually going on. In still older plants showing from seven to nine protoxylem groups, the parallel arrangement is generally to be found at the point of branching, and is tending to persist also between successive branchings; it may rapidly pass back into the radial, and *vice versâ*, through the appearance and disappearance (as the case may be) of connections between adjacent bands. In mature plants of *L. volubile*, *L. scariosum*, and *L. densum* the dorsally placed bands are for the most part mutually distinct, and strictly preserve their parallel disposition, although they may be seen now and then to join up with each other. In the larger lateral branches of limited growth of *L. volubile* and *L. scariosum* the tendency of the bands to join up with each other, and so break the parallel arrangement, is to be observed. In the case of the lateral aerial branches of *L. densum*, the ease with which the radial and parallel arrangements can pass into each other may be seen to an extraordinary degree: branches were examined which showed as many as fifteen to twenty-one protoxylem groups in their lower regions, and the arrangement was here seen passing backwards and forwards from radial to parallel most distinctly several times.

Now, it may be stated generally that it is in plagiotropic stems that the parallel type occurs, whilst in orthotropic stems the radial type of stelar arrangement is to be found. Jones* points out that the parallel type is well marked in the stem of the erect-growing species *L. obscurum* (Linn.). It is not clear from his account whether or not *L. obscurum* may be regarded as showing typically the parallel arrangement. At all events, *L. clavatum* (Linn.), *L. annotinum* (Linn.), *L. complanatum* (Linn.), *L. chamæcyparissus* (A. Br.), and *L. alpinum* (Linn.), which have plagiotropic growth, are noted by Jones as also showing parallel arrangement, as do also *L. densum*, *L. volubile*, and *L. scariosum*. *L. cernuum* has plagiotropic growth, but the fact that it shows "mixed" arrangement is considered later. Jones also notices that the radial type is characteristic of epiphytic species of *Lycopodium* which show orthotropic growth; he figures the stele of *L. squarrosum*

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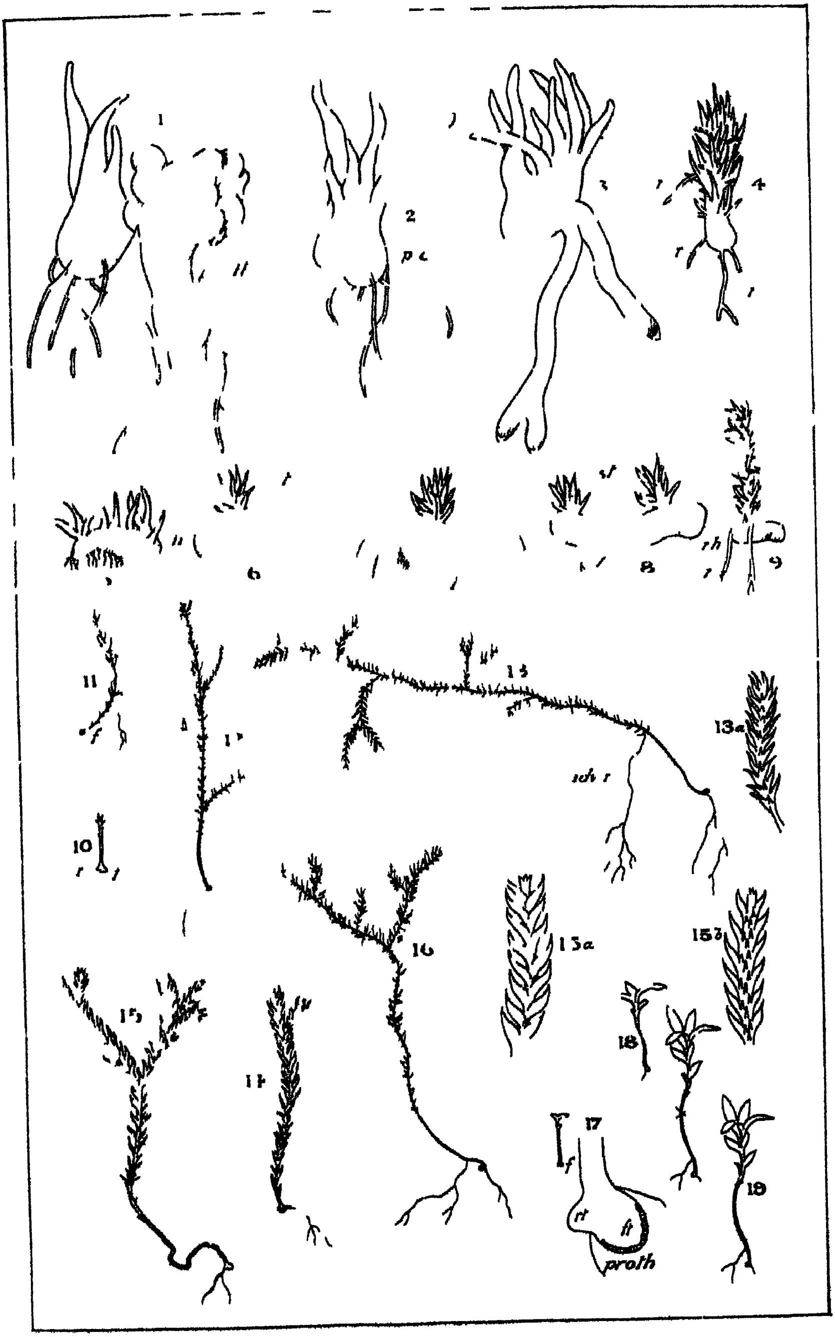
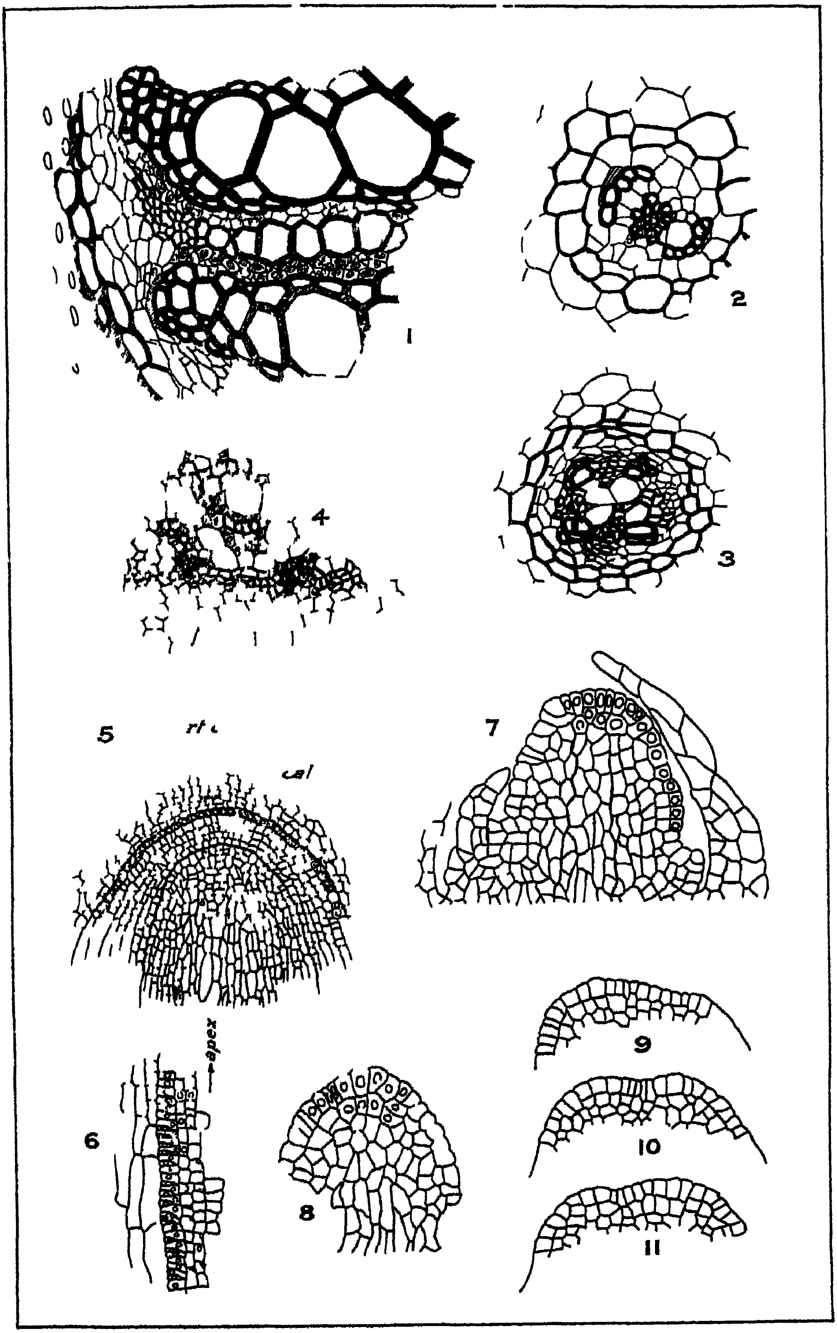
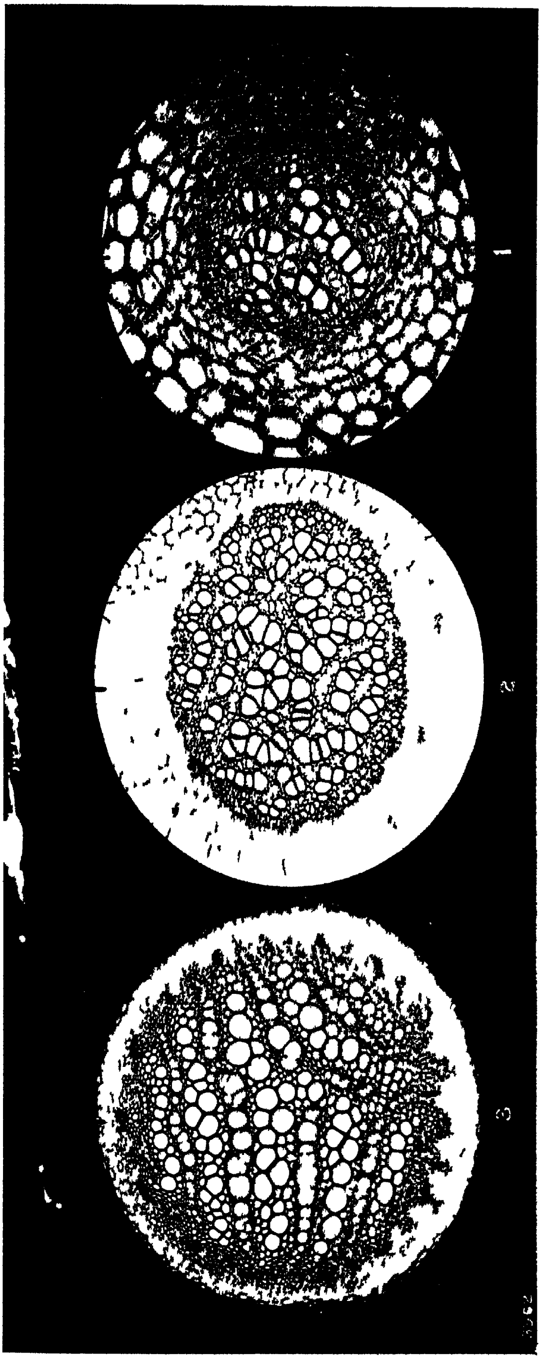
*Trans. Linn. Soc., March, 1905.



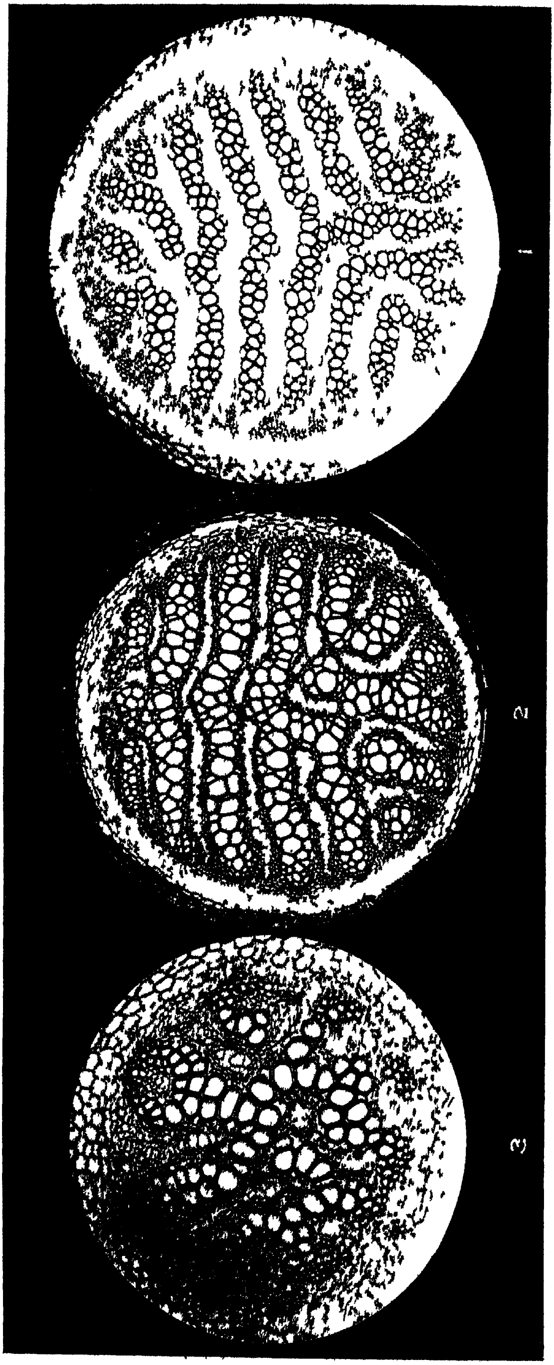
NEW ZEALAND LYCOPODIUMS.—Holloway.



NEW ZEALAND LYCOPODIUMS.—Holloway.



NEW ZEALAND SPECIES OF LYCOPODIUM —HOLLOWAY



NEW ZEALAND SPECIES OF LYCOPODIUM —HOLLOWAY

as showing radial symmetry, and notes that *L. Dalhousieanum*, *L. phlegmaria*, and *L. nummularifolium* also conform to this type. *L. Billardieri*, the epiphytic species studied here, also shows typically the radial arrangement.

The following points call for consideration as suggesting that the parallel type is but a specialisation from the radial type consequent on the restriction of stem-branching to one plane: (1.) The distinction between the two types of arrangement is not very great, as was seen from the ease with which one can pass into the other in *L. volubile*, *L. densum*, and *L. scariosum*. (2.) In *L. volubile* and *L. scariosum* the parallel arrangement makes its first permanent appearance in connection with the forking of the stele, it being an invariable rule that the disposition of the plates of tissue is always at right angles to the plane of stelar forking. (3.) In those parts of *L. volubile* and *L. scariosum* and *L. densum* where branching takes place in any plane—namely, large adventitious roots of all three species, and aerial branches especially of *L. densum*—parallel arrangement is either wholly absent (as in the former) or may be seen in the act of passing back into the radial (as in the latter).

III. *The Difference between " Mixed " and " Banded " Types.*

The view is here taken that whereas the parallel banded may be regarded as but a specialised form from the radial banded, the difference between the " mixed " and the " banded " types is far more deeply seated. The study of the early stages of *L. cernuum* and *L. laterale* on the one hand, and of *L. volubile* and *L. scariosum* and *L. Billardieri* on the other, reveals the fact that from the very first the stele of the two former shows the " mixed " arrangement of its tissues, whilst the stele of the three latter shows a very definite " banded " arrangement. The particular arrangement, then, that each shows may be regarded as belonging to its inherited constitution.

The question arises, has the nature of the dependence of the young plant upon its prothallus any significance in this connection? In the case of *L. cernuum* and *L. laterale* the prothallus is very short-lived and small, and the young plant is called upon to begin its work of assimilation at once; hence the first-formed vascular tissues in the plant is the leaf-trace system, and for a considerable time in the development of the plant the indiscriminate arrangement of the leaf-traces in the stem determines the nature of the stelar arrangement. In the case of *L. volubile* and *L. scariosum* and *L. Billardieri* the prothallus is long-lived, and the young plant feeds upon it for a long time; hence the plerome cylinder becomes strongly developed, and the leaf-traces, when they appear, affix themselves definitely to the compact protoxylem groups. This is probably the case also in *L. densum*.

Another point worthy of attention is with regard to the effect upon the developing stelar tissues that a zone of cortical sclerenchyma may have. In *L. volubile*, *L. scariosum*, and *L. densum* there is a well-developed sclerotic region in the cortex in the young plant, and this soon comes to embrace the whole of the cortex. In *L. cernuum* there is no such region, and but a feebly developed one in *L. laterale*. Possibly the presence of such a region enveloping the developing stelar tissues may serve, by imparting rigidity and lateral pressure to the tissues, to insure the greater coherency of the xylem elements into groups and bands.

EXPLANATION OF PLATES XXXI–XXXIV.

PLATE XXXI.

Figs. 1–4. Young plants of *L. cernuum.* 1, × 7; 2, × 7; 3, × 6; 4, × 3.
Figs. 5–9. Young plants of *L. laterale.* 5, × 5; 6, natural size; 7, × 3; 8, × 3; 9, × 1½.
Figs. 10–13. Young plants of *L. volubile.* 10, 11, and 12, natural size; 13, × ⅔.
Fig. 13*a*. Showing dorsi-ventrality and heterophylly in leaf-arrangement of *L. volubile.*
Figs. 14–15. Young plants of *L. scariosum.* Natural size.
Figs. 15*a*, 15*b*. Showing dorsi-ventrality and heterophylly in leaf-arrangement of *L. scariosum.*
Fig. 16. Young plant of *L. densum.* × ½.
Figs. 17–19. Young plant of *L. Billardieri.* Natural size.

PLATE XXXII.

Fig. 1. Portion of stele of mature stem of *L. volubile*, showing banded arrangement. × 175.
Fig. 2. Stele of young plant of *L. volubile*, 1 cm. high. × 225.
Fig. 3. Stele of young plant of *L. scariosum*, 1½ cm. high. × 175.
Fig. 4. Portion of stele of mature stem of *L. cernuum* just behind apex, showing mixed arrangement. × 80.
Fig. 5. Apex of adventitious root of *L. volubile.* × 125.
Fig. 6. Showing piliferous layer behind apex of adventitious root of *L. volubile.* × 175.
Fig. 7. Apex of terminal branchlet of *L. densum.* × 200.
Fig. 8. Apex of young strobilus of *L. volubile.* × 200.
Figs. 9–11. Three consecutive longitudinal sections of stem of *L. volubile*, showing dichotomous branching. × 175.

PLATE XXXIII.

Fig. 1. Photomicrograph of stele of *L. laterale.* × 95.
Fig. 2. Photomicrograph of stele of *L. cernuum.* × 38.
Fig. 3. Photomicrograph of stele of *L. volubile.* × 57.

PLATE XXXIV.

Fig. 1. Photomicrograph of stele of *L. scariosum.* × 49.
Fig. 2. Photomicrograph of stele of *L. densum.* × 47.
Fig. 3. Photomicrograph of stele of *L. Billardieri.* × 95.

ART. XLVII.—*A List of the Known Fishes of Kermadec and Norfolk Islands, and a Comparison with those of Lord Howe Island.*

By EDGAR R. WAITE, F.L.S., Curator, Canterbury Museum.

[*Read before the Philosophical Institute of Canterbury, 3rd November*, 1909.]

As a member of a small party, Mr. W. R. Oliver spent about nine months during 1908 at the Kermadec Islands, and incidentally made a collection of fishes, which he placed with me for examination. Though small, the collection is interesting, from the circumstance that very few fishes were definitely known from the group; in fact, the only references I have encountered, other than those recorded by the "Challenger" expedition (see concluding paragraph), are to *Gymnothorax cupterus* and *Scorpæna cooki*, both described from Raoul Island (Sunday Island) by Günther, though since recognised elsewhere.

Mr. Oliver explains that no serious attempt was made to secure a representative collection of the fishes; arrangements projected for obtaining a better series being frustrated by the unexpected early arrival of the Government steamer, which makes but an annual call at the Kermadec Islands.

The group lies on meridian 178 of west longitude, and the 30th parallel of south latitude passes through it. Norfolk Island lies in the same latitude, but considerably to the westward, the longitude being 168° 1′ east. Still further to the west, in longitude 159 5′ east, is Lord Howe Island; this island has a rather more southerly position, the latitude being 31° 33′ south. As the temperature of the water, or the food-supply which it maintains, is an important factor in the geographical distribution of fishes, a comparison of the fauna of the three islands mentioned, lying as they do in approximately the same parallel, may be of some interest.

Unfortunately, the fish fauna of the islands is very imperfectly and unequally known, for, while that of Lord Howe Island has been tolerably exploited, our knowledge of the fishes of Norfolk Island and of the Kermadec Group rests upon meagre records, which are here presented for the first time in collected form.

KERMADEC ISLANDS.

As above mentioned, Günther has recorded two fishes from Raoul Island—namely, *Muræna euptera** and *Scorpæna cooki*.† In his account of the Kermadec Islands, Mr. Percy Smith‡ writes, "Fish abound round the coast in great quantities. We caught hapuka (*Polyprion prognathus*)§ of great size; a variety of kahawai (*Arripis trutta*), a very handsome fish; kingfish, or yellow-tail (*Seriola lalandii*), a delicious fish, very superior for eating to our New Zealand species; and trevalli (*Caranx platessa*); besides others whose names I have no idea of." I have not come across further records, and the following is a complete list of the fishes obtained by the party. Mr. Oliver has supplied me with a few field notes, and these have been made use of where they appear to be of interest.

Among the most interesting forms are those which were previously known only from either Norfolk or Lord Howe Islands, including *Machærope latispinis*, Ogilby; *Acanthistius cinctus*, Günther; *Cantherines analis*, Waite; and *Limnichthys fasciatus*, Waite: while of special note is that interesting Paralepid, *Lestidium nudum*, Gilbert, previously known from a single example taken in the Hawaiian Islands. Examples identified with *Lampanyctus guntheri*, Goode and Bean, are described; while the following are regarded as new, and are herein figured: *Gonostoma raoulensis*, *Muræ-nichthys oliveri*, *Pempheris analis*.

An examination of the recorded species may show a slight excess of Australian over New Zealand forms; but in the majority of cases they are common to both areas, while many have a much wider range. It would appear, however, that the Kermadec, Norfolk, and Lord Howe Islands have much in common as regards the fish fauna, and that some interesting types have been developed in these groups. It is to be hoped that further collections may be made in the neighbourhood of the Kermadec and Norfolk Islands, so that a more satisfactory comparison may be made.

Carcharias (Rafinesque), sp.

Mr. Oliver says that sharks are fairly common during the summer months, and were taken off Fishing Rock, on Sunday Island. Young ones were caught from the beach. Specimens were not preserved, but Mr. Oliver has supplied notes and sketches which enable me to refer the shark to the genus *Carcharias*. The absence of black on the fins removes it from possible alliance with the common Pacific *C. melanopterus*. I recorded *C. menisorrah* from Lord Howe Island, and found it to be as common there as the species noticed by Mr. Oliver at the Kermadec Islands.

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* Günther, Cat. Fish. Brit. Mus., viii, 1870, p. 122.

† *Id.*, "Fische der Sudsee," 1874, p. 78, pl. lv.

‡ Smith, "The Kermadec Islands," 1887, Wellington, p. 22.

§ I have supplied the probable scientific names.

The shark which Mr. Moseley mentioned as having been caught with four or five pilot-fish about it was supposed by Dr. Günther to be *C. lamia*.*

Lampanyctus guntheri, Goode and Bean.

D. 13; A. 13; V. I, 8; P. 16; C. 19 + 12. L. lat. 38; L. tr. 2–4.

Length of head, 3·3; height of body 5·2 in the length; eye, 3·1; interorbital space, 4·6; and length of snout, 5·6 in the head.

Preopercle very oblique, the angle acute, the mouth large, subhorizontal, the maxilla extending to the preopercular angle.

The dorsal fin arises midway between the front margin of the eye and the base of the caudal, the length of its base 1·7 in the head; adipose fin present, immediately behind the vertical of the anal; the anal commences beneath the last ray of the dorsal, and its base is slightly less than that of the dorsal; the ventral lies beneath the second ray of the dorsal, and just reaches to the anal fin; the pectoral is very long, longer than the head, and it reaches to the middle of the anal; the caudal is deeply forked, its length being 1·3, and the least depth of its peduncle 3·6 in the head.

The scales are smooth, those of the lateral line scarcely enlarged. Luminous scales are also present on the hinder part of the caudal peduncle above, and below they extend from the anal fin to the caudal; apparently luminous scales also exist before and behind the dorsal fin; the nostril and the margin of the preopercle likewise seem to be luminous.

The photophores lie as follows:—Opercular: 3, close behind the margin of the preopercle. Pectoral: 3, one below the lateral line, one on the base of the fin, and the third above the second thoracic. Antero-lateral: 1 above the base of the ventral fin. Medio-lateral: 3, the upper one on the lateral line above the first anal ray. Postero-lateral: 2, the upper just below the lateral line over the last anal ray. Thoracic: 5, the last slightly raised and at the base of the ventral. Ventral: 5, the first and fourth below the others, and the fifth beneath the lowest medio-lateral. Anal: 11, the first the lowest, a wide break between the sixth and seventh at the base of the last anal ray. Caudal: 4, the last just below the lateral line.

The colours are of the dark hue usual with Myctophids, the dorsal, anal, and caudal being dotted, the dots forming closely set bars.

Eight specimens, washed ashore. The only example before known appears to be the type, taken off Newfoundland.

Length, 60 mm.

The points in which the specimens differ from the description of *L. guntheri* are so slight that I decide to refer them to that species, and indicate the ascertainable differences.

In the Kermadec Island examples there is but one antero-lateral photophore in place of two, and the anals number 6 + 5 as against 5 + 5. The dorsal fin also appears to have a slightly more forward position.

Two misprints in the original account, which have been copied by subsequent writers, may be here corrected: "Dorsal origin a little nearer to tip of snout than to root of ventral"; for "ventral" read "caudal." "Postero-laterals in advance of the first dorsal"; for "first dorsal" read "second dorsal."

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* Chall. Rep., Summary, pt. i, p. 617.

Gonostoma raoulensis, sp. nov. Plate XXXV, fig, 1.

D. 10; A. 10; V. 6; P. 11; C. 8 + 15; Sc. 38, Sc. tr. 9.

Length of head, 3·8; height of body, 5·4 in the length; diameter of eye, 3·4; and interorbital space, 5 in the head.

Head compressed, lower jaw the longer; the maxilla extends beyond the eye, and is toothed to its extremity; the mouth is large, and the teeth in the jaws are canine-like, of unequal size; there are teeth on the palatines, but none on the vomer. No pseudobranchiæ. Gills, 4; gill-rakers long and slender, 18 on the first arch, 13 being on the lower limb.

Body compressed. The dorsal fin commences midway between the middle of the eye and the base of the caudal; the length of its base is one-fifth less than the head; adipose fin present; the anal fin commences below the hinder third of the dorsal, and has a shorter base; the ventral fin lies midway between the end of the snout and the base of the caudal; the pectorals are inserted low, and extend more than half their distance from the ventrals; the caudal is forked, and the depth of the peduncle is less than the diameter of the eye.

The scales are large, thin, and cycloid; and on the head are present, on the opercles at least, no certain traces of lateral line.

The sides are silvery, the upper edge dark brown as far as the hinder insertion of the dorsal; dots behind the adipose fin, also at the base of the caudal peduncle: upper part of head spotted: all the fins colourless.

The photophores are arranged thus:—Preorbital: 1, immediately in front of the eye. Suborbital: 1, at the lower hinder angle. Opercular: 1 on the edge of the preopercle, 2 behind its angle, about 12 on the inner side of the opercles, continued forward towards the symphysis of the lower jaw. Mandibular: a pair at the symphysis, and 8 pairs on the isthmus—that is, a series of 8, and a corresponding series on the other side of the ventral line. Thoracic: 16 true pairs (as above), the anterior one beneath the gill-cover; also an upper series of 12 lying close above the hinder 12 pairs. Ventral: 10 pairs, an upper series of 11, the extra one lying above the ventral fin; the whole upper row thus forms an unbroken series of 23 photophores. Anal: 13 or 14 pairs, less regularly disposed, posterior to the fin. Caudal: none, unless the last 2 of the anal series, which are slightly separated, be so regarded.

Length, 41 mm.

The differences between *Gonostoma* and *Phosichthys* were indicated by Goode and Bean,* and Günther† has given an excellent figure of *P. argenteus*, that by its author being incorrect, illustrating two rows of photophores above and beyond the anal fin, instead of one row only.

Gonostoma microdon, Günther, also recorded from New Zealand, has been made the type of the genus *Cyclothone*, Goode and Bean, differing in absence of scales and usually the adipose fin also. The luminous spots are less conspicuous than in *Gonostoma*.

Maurolicus australis, Hector, is generically distinct, and will be diagnosed in a later paper.

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* Goode and Bean, Oceanic Ichth. Mem. Mus. Harv. Coll., xxii, 1896, p. 104.

† Günther, Chall. Rep., xxii, 1887, pl. xlv, fig. A.

Lestidium nudum, Gilbert. Bull. U.S. Fish Comm., xxiii, 1905, p. 607, fig. 236.

This fish was previously known only from the type specimen, taken in the Hawaiian Islands; it was obtained in the trawl, operating at a depth of 283 to 284 fathoms, but Dr. Gilbert thinks it may have been captured near the surface. It measures 200 mm. in length, and is fully described and figured.

Mr. Oliver has placed three specimens of this interesting species in my hands. They were washed on to Denham Bay beach, on Sunday Island, in July last year, and are in very good condition. They have the appearance of immaturity, no colour-markings being developed; they are smaller than the type, being respectively 129 mm., 109 mm., and 105 mm. in length.

The radial formulæ, in the order given, is as follows: D. 12, 10, 10; A. 29, 31, 32. The other fin-rays are as in the type, and in every case the scales in the lateral line number 68.

Gonorhynchus gonorynchus, Linn.

Several small examples are included in the collection; they were washed up on to the beaches, and are all similar to the young ones I have previously described,* which therefore represent the normal coloration of immature specimens. A large example, taken in this province, and preserved in the Museum, measures 384 mm. in length.

Congrellus, sp.

Several small Leptocephalid eels are recognised as of this genus, but it is not possible to identify them specifically. There are also a number of larval forms, possibly of different genera, entered in the comparative list as *Atopichthys*.

Muraenichthys oliveri, sp. nov. Plate XXXV, fig. 2.

Head acute, 11·5 in the total length; anterior nostril in a tube close to the lip, and just above the tip of the mandible; posterior nostril a large pore, midway between the anterior one and the angle of the mouth, also close to the lip; cleft of mouth one-fifth the length of the head, extending posterior to the eye; the latter small, 3·3 in the length of the snout. Gill-opening very small, a vertical slit, subventral in position. Teeth in the jaws, on the vomer and palatines. A row of large pores along the margin of the upper lip and another from the snout passing over and behind each eye; a transverse series of 5 pores across the upper anterior half of the head; the lowest pore on each side forms the first of the lateral series, which to the number of 135 passes along the middle of the side to within a head-length of the caudal; this series is arched on the head, and there are 67 pores anterior to the vent. Head and body together a little shorter than the tail. Body worm-like, its depth about $\frac{1}{49}$ the total; tail not compressed. Dorsal fin low, arising exactly in the middle of the length and a short distance posterior to the vent; anal similar to and arising slightly in front of the dorsal, and uniting with it round the end of the tail.

Colours.—Olive-brown above, the tint formed of closely placed spots, which are more widely spaced on the sides; lower parts immaculate.

Length of specimen, 207 mm.

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* Waite, Rec. Aust. Mus., v, 1904, p. 147.

Gymnothorax thyrsoidea, Richardson.

A single specimen was preserved by Mr. Oliver, who supplies the following note: "The brown eel is perhaps the most common fish among rocks inshore. At Coral Bay it occurs under almost every stone in rock-pools. The power of seeing is limited, but that of smelling is well developed. A limpet, cut from its shell, will attract several of these hideous-looking eels. No sooner is one's hand in the water than one of these fishes, if near, darts at it and drives its powerful teeth through the flesh; in drawing back the hand, as one naturally does, the teeth cut their way out of the flesh According to Mr. Roy Bell (one of the settlers on the Kermadec Islands), a pinch behind the head will have the effect of making the eel let go its hold: the eel evidently thinks another fish is attacking it."

Scombresox forsteri, Cuvier and Valenciennes.

The only specimen in the collection was washed on to the beach on the 1st July, 1908.

Machærope latispinis, Ogilby.

Previously known only from Lord Howe Island, we now have four examples from the Kermadec Islands, they having been washed up on to the beach at Sunday Island in August, 1908.

Seriola lalandii, Cuvier and Valenciennes.

Mr. Oliver states that the kingfish was often seen off the rocks, swimming solitarily or in parties of two or three. While out in the boat in Denham Bay on the 4th May, 1908, he saw a large school of young kingfish, averaging 22 in. in length, several of which were caught. Specimens were preserved for identification.

Caranx platessa, Cuvier and Valenciennes. (= *C. georgianus*, C. & V.)

According to Mr. Oliver, the trevalli is not common at the islands, and was caught on one or two occasions only, off the rocks and beach; the length of the largest example obtained was 640 mm.

Cubiceps gracilis, Lowe.

The specimens referred to this species are rather small for specific recognition, but they agree very closely with Günther's figures* of the smaller examples illustrated.

Schedophilus maculatus, Günther.

The largest of three specimens received measures 100 mm. in length. and the dark blotches on the body form four bands, the three anterior of which are double. In the specimen figured from Lord Howe Island† the tail was imperfect, and was indicated as supposedly rounded; the present examples show it to be emarginate, and about one-fifth the length of the head and body.

Pempheris analis, sp. nov. Plate XXXVI.

B. VII; D. VI, 9; A. III, 31–34; V. I, 5; P. 16; C. 17 + 6. L. lat. 69 + 18; L. tr. 13 + 23.

Length of head, 3·4; height of body, 2·4 in the length; diameter of eye, 2 in the head; interorbital, 1·6; snout, 3·1 in the eye.

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* Günther, Chall. Rep., xxxi, 1889, pl. ii, figs. B and C.

† Waite, Rec. Aust. Mus., v, 1904, pl. xx, fig. 1.

The maxilla is slightly longer than the diameter of the eye, is greatly expanded behind, its distal extremity being one-third the diameter of the eye, and extending slightly beyond its centre. Two small flat spines at the angle of the premaxilla. The cleft of the mouth is nearer the vertical than horizontal, and at its angle on the outside of the mandible there is a fatty body, resembling a luminous organ; this is only visible when the mouth is open.

A narrow band of setiform teeth in the jaws, on the vomer and palatines.

The distance between the origin of the dorsal fin and the end of the snout is slightly less than one-half that between its origin and the tip of the middle rays of the caudal; the first soft ray is the longest, 1·2 in the head, and longer than the base of the fin, which is 1·4 in the same. The anal fin commences beneath the middle of the dorsal, and its base is an eye-diameter longer than the head. The pectoral is long, extending to the base of the first anal ray; its third ray is the longest, a little longer than the head less the snout; its lower rays diminish rapidly, the inferior ones being very short. The ventral does not quite reach to the anal. The upper lobe of the caudal appears to be the longer, due to its upper rays being nearly in the same line as the dorsal profile from the origin of the dorsal fin; the caudal is emarginate, and its length 1·4 in the head; the depth of the peduncle is equal to its length below.

Scales.—With the exception of the upper part of the snout, the whole of the head is covered with ctenoid scales similar to those of the body; the bases of the anal and caudal are clothed with smaller scales, which run up the interradial membranes for some distance. The lateral line follows the dorsal profile, and is continued along the middle of the caudal.

Colours.—Purplish-brown, not darker above than below, lower parts of head lighter, a golden spot behind the eye; dorsal, caudal, and paired fins yellow; anal grey; spines and tip of dorsal and axis and base of pectoral black; first few rays of anal also black.

Length, 189 mm. Nine specimens.

This species is very nearly allied to *P. oualensis*, Cuv. & Val.* (= *P. otaitensis*, Cuv. & Val.), differing mainly in the constant smaller number of rays in the anal; those of the latter species are rendered as 40–42 also by Günther,† and as 41 by Seale;‡ the maximum number found in *P. analis* is 34, and the minimum 31. Some slight proportional differences are also observable, but can be definitely ascertained only by direct comparison. The colour scheme appears to be identical, and specimens showing connection in the matter of the rays may some day be found.

Mr. Oliver informs me that all examples obtained were washed up on to Denham Bay beach on several occasions between May and September, 1908; at one time fifteen were on the beach, but most of them were gnawed by rats.

Polyprion prognathus, Forster.

Though specimens of the groper were not preserved, I have no hesitation in including this species. Mr. Oliver not only identified it himself, but he made a description which enables me to confirm his statement. He supplies notes of two specimens caught, one in March and the other in September, 1908.

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* Cuvier and Valenciennes, Hist. Nat. Poiss., vii, 1831, pp. 299, 304.

† Günther, Cat. Fish. Brit. Mus., ii, 1860, p. 508.

‡ Seale, Occ. Papers Bern. Bishop Mus., i, 1901, p. 74.

Trachypoma macracanthus, Gunther.

The collection contains two examples, the larger of which, measuring 228 mm. in length, was taken off the rocks at Sunday Island by hook and line. It is thus much larger than the type, which measured 180 mm. Both examples agree absolutely in structure with the diagnosis and figure of the species,* but differ in coloration. Instead of being uniform, the head and body are mottled with brown, and, though the specimens agree, the markings are better defined in the smaller fish, which is 110 mm. long. The top of the head is brown, and there is a V-shaped mark on the cheek, the front limb of which lies below the eye; there are four irregular brown blotches across the back, one in advance of the dorsal, a second at the base of the last six spines, a third below the middle of the rays, and the fourth across the base of the caudal; the blotches beneath the fins are also continued some distance up their bases; a brown band passes from the snout behind the eye, and is represented along the lateral line by a series of large irregular blotches, which are generally alternate with the dorsal marks. The characteristic spots, which, as I know from fresh specimens collected at Lord Howe Island, are blue in life, are not very apparent in the Kermadec Island examples, but may be traced on the fins, and faintly on the body in places; they would be doubtless more conspicuous when the fish was alive.

This species is now known from Norfolk Island (the type locality), Lord Howe, and the Kermadec Islands.

Acanthistius cinctus, Gunther.

The largest example brought from the island measures 330 mm. in length. Mr. Oliver says that it is very common among rocks all round the coast, and is greedy, and easily caught.

Arripis trutta, Forster.

The kahawai is extremely common at the islands, and Mr. Oliver says that during the months of September and October they literally swarmed round the island, feeding on a small crustacean; on the 8th September, when Denham Bay was crowded with kahawai, many were caught, and the stomachs of all were full of the crustaceans. Examples caught in April were in roe. Two specimens were preserved for examination.

Girella cyanea, Macleay.

I referred several small specimens to this common Lord Howe Island species, but, as they showed some slight differences, I referred them to Mr. A. R. McCulloch, of the Australian Museum, for the purpose of comparing them with the examples we together collected there in 1902–3. He says that, compared with specimens of the same size, they differ only by having the ventrals reaching nearly to the vent, whereas in all others they fall short of it. He adds that the Lord Howe Island examples show some variation in this respect, and he would regard the Kermadec Island examples as referable to this species. The life colours as described by Mr. Oliver are exactly those of *Girella cyanea.*

Scorpis æquipinnis, Richardson.

This Australian species, known also from Lord Howe Island, differs from the New Zealand *S. violaceus*, Hutton, by its larger scales. Three small examples were collected on Sunday Island.

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* Boulenger, Cat. Fish. Brit. Mus. (2), i, 1895, p. 146, pl. ii.

Atypichthys strigatus, Gunther.

Of this widely distributed species we have three examples from the Kermadec Islands. Mr. Oliver states that they are common among rocks all round the coast.

Goniistius gibbosus, Richardson.

The distinguishing features of the members of the genus *Goniistius* have not yet been clearly expressed, and await investigation at the hands of some worker with a representative series. The only example received from the islands is in fair agreement with Steindachner's figure,* but the oblique bands are not so well defined, and the last, or eighth, band does not run on to the tail; the anal fin, also, is black. The rays of the dorsal fin number XVII, 33; those of the anal III, 8. The specimen measures 221 mm. in length.

Chironemus marmoratus, Günther.

Several specimens, taken among rocks.

Chromis, sp.

The only member of the *Pomacentridæ* secured is a scaleless and otherwise mutilated specimen found on the beach. It is not possible to identify it specifically, but the following characters may be mentioned: Body less than half the length; second anal spine very long and strong, longer than the longest dorsal spine; pectoral longer than the head, and one-third the length of the body; tail long and deeply forked, its lobes acute; the caudal peduncle is slender, its depth one-third greater than the diameter of the eye. It is not possible to ascertain the coloration, but traces of orange exist about the opercles and at the bases of the fins. The length of the specimen is 160 mm.

Pseudolabrus inscriptus, Richardson.

Previously recorded from Raoul Island.

Pseudolabrus luculentus, Richardson.

Represented by small examples taken from rock-pools.

Cantherines analis, Waite.

Pseudomonacanthus analis, Waite. Rec. Aust. Mus., v, 1904, p. 173, fig. 32.

I associated with this species an example obtained at Sunday Island, but noted differences in respect to the situation of the gill-opening and the pectoral. The type being preserved in the Australian Museum, I forwarded the specimen to Mr. McCulloch, who kindly writes as follows: "The specimen is undoubtedly *Pseudomonacanthus analis*. The type, as you will remember, is imperfect and beach-worn, and the positions of the gill-opening and pectoral are consequently not quite correctly shown in the figure. The small black spots seen in the Kermadec Island specimen may be traced in the type."

In my paper I made comparison with *P. degeni*, Regan,† and now, having an example for direct comparison, Mr. McCulloch writes, "*P. degeni* is much more slender than *P. analis*, the caudal peduncle is longer, and the spine is over the hinder margin, and not over the middle of the eye."

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* Steindachner and Döderlein, Fische Japans, ii, 1883, pl. vii, fig. 2.

† Regan, Proc. Zool. Soc., 1902, p. 299, pl. xxiv, fig. 1.

As the present example is in perfect condition, the original description may be amended and amplified as follows :

D. II, 35; A. 32; P. 12; C. 12.

The upper edge of the gill-opening stands under the middle of the eye, and the insertion of the pectoral is beneath the same point. As in the type specimen, the dorsal spine is also broken; the existing portion measures one-half the length of the snout.

The colour and markings are as previously described, but in addition the upper part of the body and caudal peduncle are ornamented with closely set small black spots, which do not extend below the mid-line of the body.

The specimen is somewhat larger than the type, being 280 mm. in length.

Sphæroides oblongus, Bloch.

Represented by one specimen only.

Canthigaster caudofasciatus, Günther.

Two little examples received, which measure but 31 mm. and 33 mm. in length respectively. The smaller one is colourless, but the other exactly resembles Steindachner's figure.* This author regards *Tetrodon callisternis*, Ogilby, as the same species. *C. caudofasciatus* is identified from Laysan, while *C. callisternis* was described from examples collected on Lord Howe Island. My little specimens do not enable me to form any opinion on the identity of the two forms.

Diodon hystrix, Linnæus.

Among the specimens washed on to Denham Bay beach are two little Diodons, measuring respectively 27 mm. and 12 mm. in length. They have been referred to *D. hystrix*, because it is not possible in such small specimens to find characters which may be distinctive, and which in adult examples may be of doubtful value.

Scorpæna cooki, Günther.

Jordan and Evermann† state that the illustration made by Garrett, and published by Gunther as *S. cooki*, was from an Hawaiian species—*S. cacopsis*, Jenkins—the description only referring to the Raoul or Kermadec Island species.

Mr. Oliver informs me that this fish, two examples of which he submitted for determination, is not uncommon on rocky bottoms, and was occasionally caught. The largest specimen secured measured 475 mm.

Pterois volitans, Linnæus.

Mr. Oliver writes, "Only a single specimen was taken, being obtained with a scoop net in the boat-harbour at Meyer Island on the 24th April, 1908. It is a most gorgeously coloured fish, which moved along very slowly, near the bottom, and allowed itself to be driven to a corner, where it was netted. Evidently it was conscious of the terrible weapons it possessed in its spines, and made but a feeble attempt to escape. I take it to be a good case of warning coloration."

Limnichthys fasciatus, Waite.

Mr. Oliver's collection contains several examples of this species, taken in rock-pools, and also dredged from 5 fathoms at Sunday Island. They show some diversity in colour-pattern, the number of cross-bands varying from seven to ten. In most cases these bands unite on the lateral line and form a longitudinal stripe, the whole of the body below this being without markings. All the structural characters agree with the type.

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* Steindachner, Denk. d. k. Akad. Wiss., Wien, lxx, 1900, pl. iii, fig. 3.

† Jordan and Evermann, Bull. U.S. Fish. Comm., xxiii, 1905, p. 468.

Alticus, sp., and Salarias, sp.

Examples of these two genera have not been specifically determined.

(?) Petroscirtes rhynorhynchus, Bleeker.

A small example, 48 mm. in length, is provisionally referred to this species. It was dredged in 12 fathoms, off Meyer Island.

NORFOLK ISLAND.

The first fish recorded from Norfolk Island appears to be *Cichla cultrata*, Forster,[*] obtained during Cook's second voyage, 10th October, 1774. In Forster's "Descriptiones Animalium"[†] there is a list of fishes taken between New Caledonia and Norfolk Island, but the same species, under the name *Sciæna cultrata*, is the only one recorded from Norfolk Island (p. 292). Richardson added a few species, all of which, with the exception of *Muræna nubila*, are included in Bleeker's list, given below.

The first collected list of fishes from Norfolk Island is that by Bleeker,[‡] who enumerates the following species:—

	Recognition.
1. *Centropistes salar*, Richds. = *Arripis salar*, Richds.	*Arripis trutta*, Forster.
2. *Lethrinus chrysostomus*, Richds.	*Lethrinus chrysostomus*, Rich.
3. *Psettus argenteus*, Richds. = *Chætodon argenteus*, L.	*Monodactylus argenteus*, Linn.
4. *Cybium clupeoideum*, Cv. = *Scomber clupeoides*, Brouss.	(?)
5. *Seriola cultrata*, Richds. = *Sciæna cultrata*, G. Forst. = *Cichla cultrata*, Bl. Schn. = *Scomber clupeoides*, Shaw. (An forte ead. ac. *Tybium clupeoideum*, Cv. ?)	*Bathystethus cultratus*, Forster.
6. *Tautoga inscripta*, Richds. = *Labrus inscriptus*, Richds.	*Pseudolabrus inscriptus*, Rich.
7. *Tautoga luculenta*, Richds. = *Labrus luculentus*, Richds.	*Pseudolabrus luculentus*, Rich.
8. *Chanos salmoneus*, Cv. = *Mugil salmoneus*, J. R. Forst. = *Mugil lavaretoides*, Sol. = *Lutodeira salmonea*, Richds. = *Leuciscus (Ptycholepis) salmoneus*, Richds.	*Chanos chanos*, Forskal.

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[*] Bloch and Schneider, Syst. Ichth., 1801, p. 343.

[†] Ed. Lichenstein, 1844, p. 280 *et seq.*

[‡] Bleeker, Verhand. der Koninkl. Akad. van Wetens, 1855.

Günther* added other genera and species (*Trachypoma macracanthus*, *Scorpæna cooki*, *Peltorhamphus novæ-zealandiæ*); and in 1887 Ogilby† examined a small collection of eight species, and described two as new (*Apogon norfolcensis* and *Coris trimaculatus*). He‡ later described a new mullet under the name *Cestræus norfolcensis*. I§ have previously referred to Richardson's record of a spotted *Oplegnathus* from Norfolk Island, which he had seen at the Museum at Fort Pitt, and which he mentions in writing of *Oplegnathus punctatus*.‖ The fish referred to has not since been noted at Norfolk Island. Jordon and Fowler¶ supply the data respecting Castelnau's genus and species, which at the time I wrote were unknown to me. The reference is as follows: *Ichthyorhamphos*, Castelnau, Poiss. Afrique Austr. (date 1855), p. 35 (pappei).

Some years ago, when in Sydney, I made a rough list of the fishes of Norfolk Island, based on collections made for or by Dr. Metcalfe, Messrs. Wetherall, Nobbs, and Quintal. This list is a quite unsatisfactory one, but, as I cannot now refer to the specimens, I simply print it as it stands; it will serve as a basis for future work, when the specific gaps can be filled in and new records added. Mr. McCulloch tells me that he has received *Mugil dobula* (? *M. cephalus*) from an inland stream which has been cut off from the sea for six years. This is the only species added to my original list.

Chanos chanos, Forskal.
Anguilla australis, Richardson.
Gymnothorax nubilus, Richardson.
Hyporhampus intermedius, Cantor.
Scombresox forsteri, Cuvier and Valenciennes.
(?) *Mugil cephalus*, Linnæus.
Myxus elongatus, Günther.
Agonostomus.
Cestræus norfolcensis, Ogilby.
(?) *Cybium clepeoideum*, Broussonet.
Caranx platessa, Cuvier and Valenciennes.
Bathystethus cultratus, Forster.
Amia novæ-guinea, Günther.
Epinephelus dæmeli, Günther. (Recorded by Boulenger.**)
Trachypoma macracanthus, Günther.
Acanthistius cinctus, Günther.
Cypselichthys japonicus, Doderlein.
Oplegnathus, sp. (Richardson).
Pagrus auratus, Forster.
Lethrinus chrysostomus, Richardson.
Girella.
Monodactylus argenteus, Linnæus.
Scorpis æquipinnis, Richardson.
Aplodactylus.
Chironemus marmoratus, Günther.
Chromis.
Parma polylepis, Günther.
Glyphisodon.
Thalassoma lunaris, Linnæus.
Coris trimaculata, Ogilby.
Pseudolabrus inscriptus, Richardson.
Pseudolabrus luculentus, Richardson.
Chilomycterus.
Peltorhamphus novæ-zealandiæ, Günther.

LORD HOWE ISLAND.

The fishes of Lord Howe Island have received much more attention, principally at the hands of Mr. J. D. Ogilby and myself. The list published by the former in 1889* contained eighty-eight species, while mine, issued fifteen years later,† embraced 180 species.

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* Günther, Cat. Fish. Brit. Mus., and Fische der Mus. Godeffroy.
† Ogilby, Proc. Linn. Soc. N.S.W. (2), ii, 1887, p. 990.
‡ *Id*., *ib*., xxii, 1897, p. 80.
§ Waite, Rec. Aust. Mus., iii, 1900, p. 215.
‖ Richardson, Rep. Brit. Assoc., 1845, p. 247.
¶ Jordan and Fowler, Proc. U.S. Nat. Mus., xxv, 1902, p. 76.
** Boulenger, Cat. Fish. Brit. Mus. (2), i, 1895, p. 224.

COMPARISON OF GENERA.

The following table includes all the genera (see the note at end of next page) recorded from the Kermadec and Norfolk Islands, and in the column headed "Lord Howe Island" only those genera are tabled. The complete list has been referred to above.

Genus.	Kermadec Islands.	Norfolk Island.	Lord Howe Island.
Carcharias	x	..	x
Chanos	..	x	..
Lampanyctus	x	..	..
Gonostomus	x	..	..
Lestidium	x	..	..
Gonorhynchus	x	..	x
Anguilla	..	x	x
Leptocephalus	..	..	x
Congrellus	x	..	x
Atopichthys	x	..	x
Murænichthys	x	..	x
Gymnothorax	x	x	x
Hyporhamphus	..	x	x
Scombresox	x	..	x
Mugil	..	x	..
Myxus	..	x	x
Agonostomus	..	x	..
Cestræus	..	x	..
(?) *Cybium*	..	x	..
Machærope	x	..	x
Seriola	x	..	x
Caranx	x	x	x
Bathystethus	..	x	x
Cubiceps	x	..	x
Schedophilus	x	..	x
Pempheris	x	..	..
Amia	..	x	x
Epinephelus	..	x	x
Polyprion	x	..	..
Trachypoma	x	x	x
Acanthistius	x	x	x
Arripis	x	x	x
Cypselichthys	..	x	..
Oplegnathus	..	x	..
Pagrus	..	x	x
Lethrinus	..	x	x
Girella	x	x	x

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* Ogilby, Mem. Aust. Mus., ii, 1889, p. 52.

† Waite, Rec. Aust. Mus., v, 1904, p. 187.

COMPARISON OF GENERA—*continued.*

Genus.	Kermadec Islands.	Norfolk Island	Lord Howe Island
Monodactylus	..	x	..
Scorpis	x	x	x
Atypichthys	x	..	x
Goniistius	x	..	x
Aplodactylus	..	x	x
Chironemus	x	x	x
Chromis	x	x	x
Parma	..	x	x
Glyphisodon	..	x	x
Halichœres	..	..	x
Thalassoma	..	x	x
Coris	..	x	x
Pseudolabrus	x	x	x
Cantherines	x	..	x
Sphæroides	x	..	x
Canthigaster	x	..	..
Diodon	x	..	x
Chilomycterus	..	x	..
Scorpæna	x	..	x
Pterois	x	..	x
Limnichthys	x	..	x
Alticus	x	..	x
Salarias	x	..	x
Petroscirtes	x	..	x
Peltorhamphus	..	x	..

The following genera were represented at Stations 170 or 170A of the "Challenger" Expedition, when the trawl was lowered off the Kermadec Islands in 520 and 630 fathoms: *Macrurus* (four species), *Bathygadus*, *Gonostoma*, *Bathypterois*, *Scopelus*, also "pilot-fish." As, however, no deep-sea investigations were conducted off Norfolk or Lord Howe Islands, these genera are not included in the comparative list.

EXPLANATION OF PLATES XXXV AND XXXVI.

PLATE XXXV.

Fig. 1. *Gonostoma raoulensis*, sp. nov.
Fig. 2. *Murænichthys oliveri*, sp. nov.

PLATE XXXVI.

Pempheris analis, sp. nov.

ART. XLVIII.—*Notes on New Zealand Fishes.*

By EDGAR R. WAITE, F.L.S., Curator, Canterbury Museum.

[*Read before the Philosophical Institute of Canterbury, 1st December, 1909.*]

1. Cephaloscyllium sabella, Broussonet.

IN acknowledging the receipt of a copy of my paper on the "Scientific Results of the New Zealand Government Trawling Expedition," Mr. J. Douglas Ogilby wrote to me as follows: "I think you will have to change the name *Cephaloscyllium laticeps*, Dumeril, to *C. sabella*, Gmelin or Broussonet, Syst. Nat., p. 1489."

Like Mr. Ogilby, I am unable to consult Broussonet's paper, but the following, translated from Gmelin,[*] appears to be his diagnosis :—

"Species with an anal fin and spiracles.

"*Squalus sabella.*—First dorsal fin opposite to the ventrals. Brousson. act. Paris, 1780, p. 648, n. 1. Habitat in New Zealand, named from its coloration, spotted with black; entirely white below; 2½ ft. long; depressed in front; allied to *caniculæ*, head greatly depressed, and the shark is distinguished by the position of the first dorsal fin.

"Head short, broad, obtuse; eyes deeply set, pupil oblong, iris bronze-coloured; teeth compressed, short, triangular, acute, with a small basal cusp, disposed in six series; tongue thick, short, very obtuse; spiracle round, of moderate size; dorsal fins subquadrate, the second opposite to the anal; pectorals very large, originating near to the third gill-opening; ventrals separate, pointed behind; lateral line near to and parallel to the back."

This description, applied to a New Zealand shark, can refer only to *Cephaloscyllium*, and, as Dumeril's[†] name *Scyllium laticeps* was not published until 1853, the earlier one of Broussonet will have to be used, and I have to thank Mr. Ogilby for drawing my attention to the fact.

2. Centrophorus plunketi, sp. nov. Plate XXXVII.

In August last Messrs. Dennis Brothers, fishmongers, of Christchurch, sent a shark to me for determination, and subsequently presented it to the Canterbury Museum. It was caught by hook and line off Kaikoura, about 100 miles north of Christchurch, by Mr. A. D. Goodall, who has kindly furnished me with the following particulars: "The shark was one of three caught by my mate and me on the 13th August, one mile from shore, off Riley's Islands, in 120 fathoms of water. We have never seen its like before; but two fishermen say they have caught one each in the same locality — one before our lot, and one, 'a very large one,' since. The bottom of the sea in the vicinity of where the specimen was taken is a mud terrace with steep sides, and with rocky cliffs in places. By going a few chains to seaward of where we were anchored you may get 200 to 300 fathoms and more. Although deep fishing is done on other grounds in the neighbourhood, none of these sharks has been caught."

The shark belongs to the genus *Centrophorus*, a genus not hitherto recognised from New Zealand, and is regarded as being new to science. It

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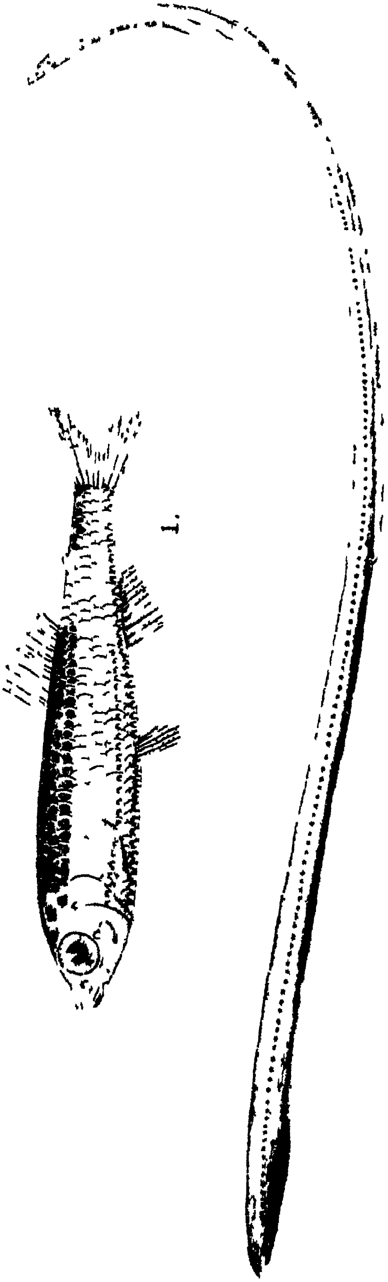
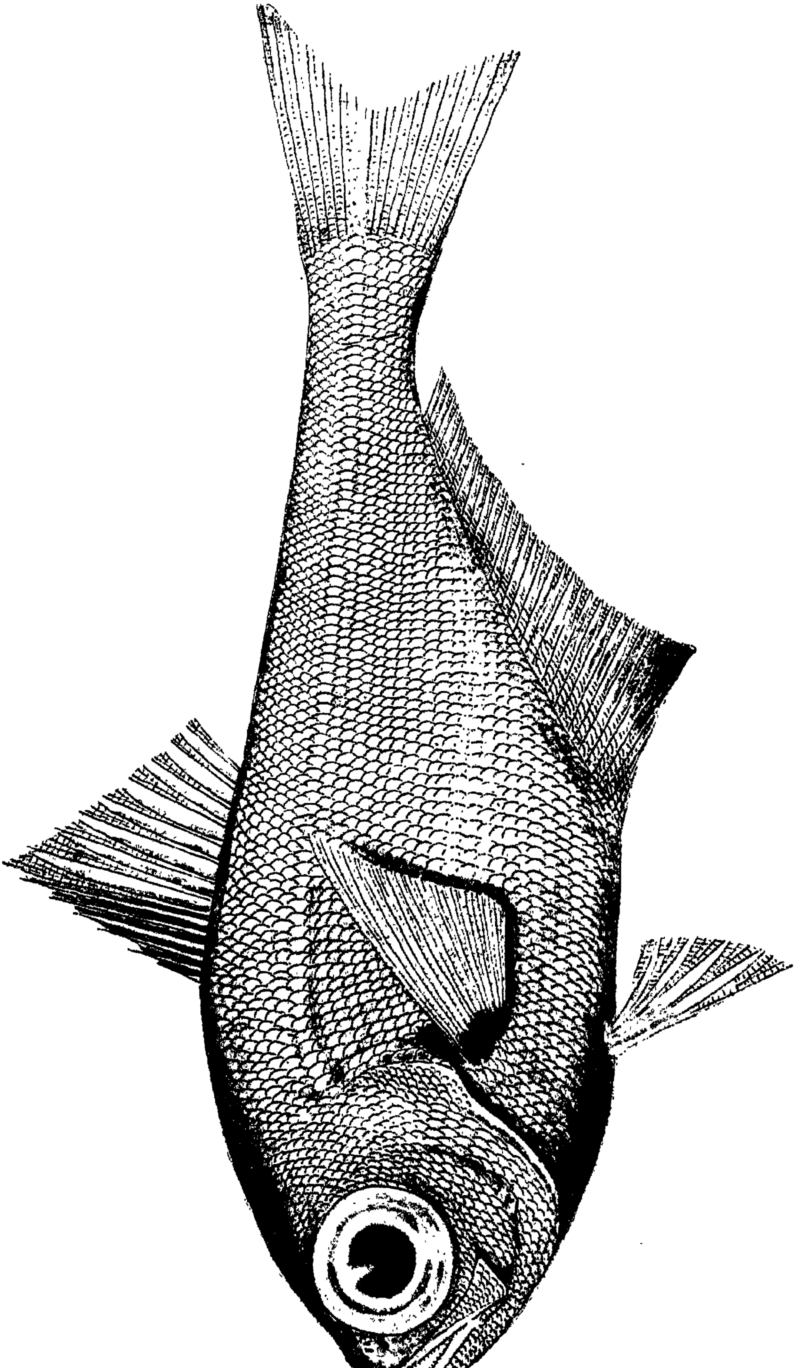
[*] Gmelin, Syst. Nat., ed. xiii, 1789, p. 1489.

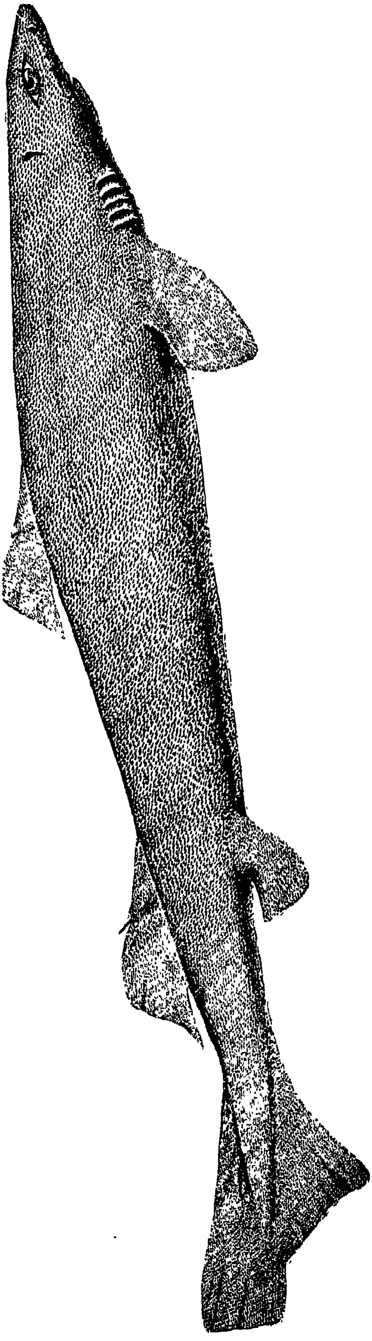
[†] Dumeril, Rev. et Mag. Zool., 1853, p. 84.



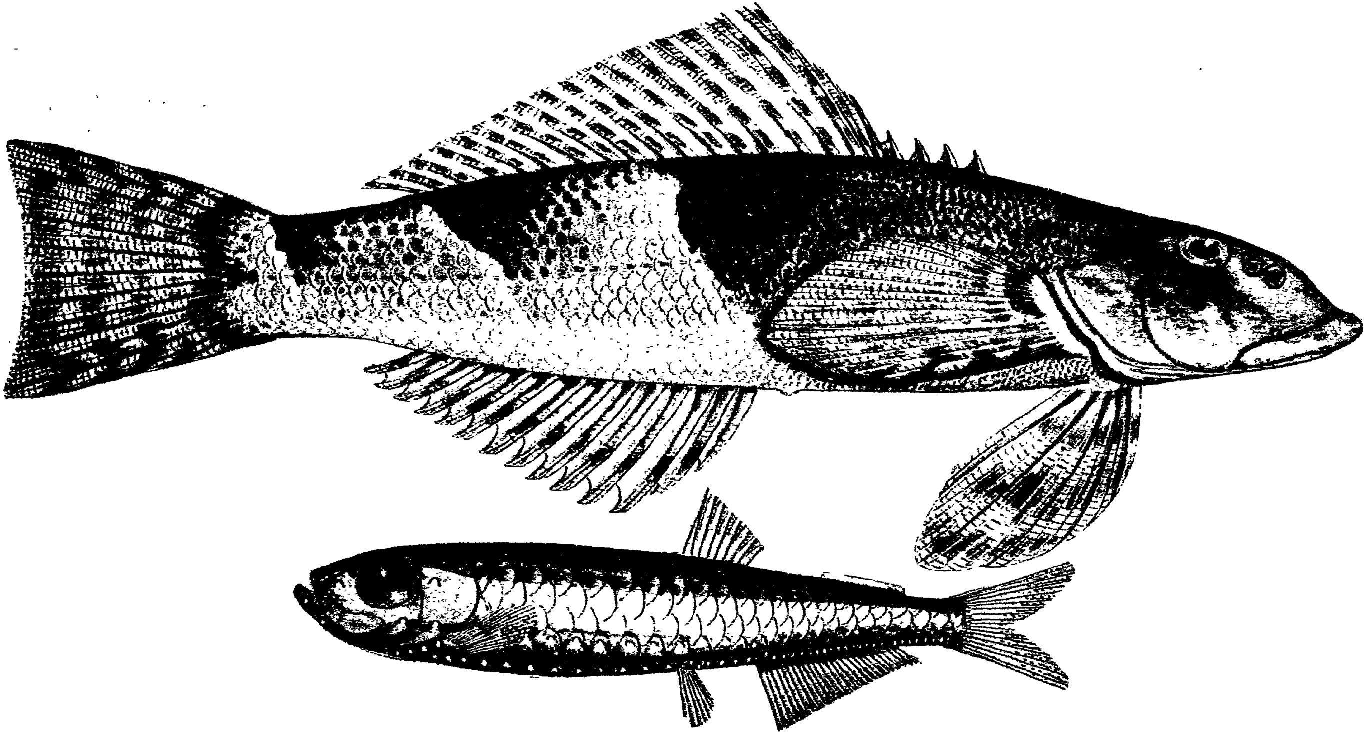
FISHES OF THE KERMADEC AND NORFOLK ISLANDS.—WAITE.



FISHES OF THE KERMADEC AND NORFOLK ISLANDS.—Waite.



NEW ZEALAND FISHES.—Waite.



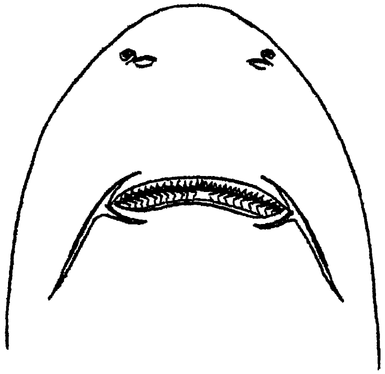
NEW ZEALAND FISHES.—Waite.

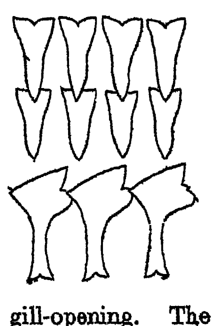
is most nearly allied to *C. foliaceus*, Gunther,* from Japan, a fact readily ascertainable by consulting the admirable "Synopsis of the Sharks of the Family Squalidæ," by Regan.† The first character used in diagnosing the species of the genus *Centrophorus* is that of the condition of the posterior or inner angle of the pectoral fin—(1) not, or but slightly, produced; (2) considerably produced and acutely pointed.

According to the synopsis, *C. foliaceus* and *C. steindachneri*, Pietschmann,‡ are nearly allied, and are placed under the first division. Judging only from descriptions and figures, the association does not seem to be close, for while *C. foliaceus* agrees in having the angle of the pectoral not at all produced, *C. steindachneri* is thus described: "Die innere (Kante der Pectoralen) in eine nach hinten gerichtete Spitze ausgezogen." The figure,§ which appears to have been issued later, and after Mr. Regan's paper was published, also shows a very decided acuteness of the pectoral lobe. Pietschmann himself states that his species is most nearly allied to *C. foliaceus*, but differs, among other characters, in the "form of the pectoral."

Length of head, 4·6; caudal, 4·7 in the length to the base of the caudal; diameter of eye, 5; interorbital space, 2·4; length of snout, 4·5; width of snout, 2·3 in the head; width of spiracle, 2·1 in the eye and 3·5 in the interspiracular space.

Head broad, greatly depressed, and flat above; eye large, the lateral cavity much longer than the eyeball, and recessed before and behind. Nostrils on lower side of snout, nearer to its tip than to the eye; their distance apart one-fifth greater than the diameter of the eye and 1·86 in the preoral portion of the snout. Mouth wide, its width half the length of the head; it lies nearer the end of the snout than to the first gill-opening. A strong fold across the angle; its length only one-fourth less than the width of the mouth; the preangular portions together occupy more than one-half the width of the upper lip; the post-angular portion is the longer and reaches to beneath the spiracle; the lower labial fold is shorter than that of the upper lip. Teeth in the upper jaw small, very acute, lying in four rows, and two-rooted, those of the lower jaw with an upper oblique cutting-edge and a laterally directed cusp; there is only a single row, formed of 30 teeth (teeth in centre of mouth lost). Spiracle large, a little nearer the eye than the gill-opening. The latter are subequal and low, being only half the diameter of the eye; the last one is immediately in front of the pectoral fin.





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* Günther, Chall. Rep., Zool., "Deep-sea Fishes," xxii, 1887, p. 5, pl. ii, fig. A.

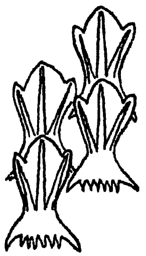
† Regan, Ann. Mag. Nat Hist. (8), ii, 1908, p. 39.

‡ Pietschmann, Anz. Akad. Wien, xx, 1907, p. 394.

§ *Id.*, *loc. cit.*, cxvii 1908, p. 667, pl. i, fig. 1.

Fins.—Dorsal spines short, not half the height of the fins. The base of the first spine lies midway between the front edge of the eye and the base of the second spine; the length of its base, excluding the spine, is slightly more than one-fifth the distance between the two fins. The second fin is much larger than the first, and its basal length from the front edge of the spine is rather less than the space between its hinder insertion and the base of the caudal. The pectoral is large, its length being equal to the distance from the tip of the snout to the first gill-opening; its inner angle is rounded, and the fin does not reach nearly to below the fleshy part of the first dorsal. The ventral is placed very far back, a third of its base lying posterior to the root of the second dorsal spine. Caudal deep, with a pronounced lower lobe.

Scales.—The scales on the tip of the snout are granular, forming mosaic; those on other parts of the head and the whole of the body and fins are imbricate, strongly tricarinate, and tricuspid. The lateral ridges and cusps as strong as the median ones, but not quite so long. Each scale has numerous (up to 8) roots.



Colour.—Uniform dark brown.

Length (a female), 1,414 mm.

The anterior position of the eye, the greater relative length of the pectoral (inserted midway between the snout and the first dorsal), the character of the second dorsal being longer than the first, and the backward position of the ventral, are points of difference between this species and *C. foliaceus.* The teeth also appear to be different, the upper series being much larger and more acute and disposed in more rows, and the lower ones with a less horizontal cutting-edge and a single row only, two rows being figured in *C. foliaceus.* The dermal denticles are apparently more strongly keeled, with more pronounced lateral cusps, the latter being not so much smaller than the median one. The character of the roots in *C. foliaceus* has not been described.

With His Excellency's kind permission, I have dedicated this new species to Lord Plunket, Governor of the Dominion, recognising his interest in the Canterbury Museum, and gratefully remembering His Excellency's kindness when, as his guest, I accompanied him on his cruise to the southern islands of New Zealand in 1907.

3. Triarcus australis, Hector. Plate XXXVIII, fig. 1.

This species was originally described by Hector[*] under the genus *Maurolicus,* but Hutton,[†] noting the presence of scales, removed it to *Gonostoma.* In his Index, however, he[‡] appears to have overlooked his previous note, and reverts to *Maurolicus,* under which name I catalogued it. A re-examination of the specimens identified by Hutton, which are preserved in the Canterbury Museum, and were taken in the Province of Canterbury, reveals the remarkable fact that they possess but three gills, instead of the four characteristic of the *Malacopterygii.* The association with the *Gonostomidæ* may thus be severed; the peculiarity, coupled with other features, merits at least generic recognition.

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[*] Hector, Trans. N.Z. Inst., vii, 1875, p. 250, pl. xi.

[†] Hutton, *ib.*, viii, 1876, p. 215.

[‡] *Id.*, "Index Faunæ Novæ-Zealandiæ," 1904, p. 50.

TRIARCUS, gen. nov.

Differs from *Gonostoma* in having only three gills, the dorsal fin not behind the ventrals, and the adipose fin low and very long.

The following is a description of the larger of the two examples:—

D. 9; A. 26; V. 8; P. 15; C. 22 + 10; Sc. circ. 26; Sc. tr. 5 + 6.

Length of head, 3·7; height of body, 4·3 in the length; diameter of eye, 2·8; length of snout, 3·5; and interorbital space, 4·6 in the head.

Head compressed; mouth small, subvertical; lower jaw the longer; the maxilla extends to below the middle of the eye; teeth in the jaws small and uniform, extending the whole length of the maxilla; no teeth on the vomer or palatines; no pseudobranchiæ. Gills, 3; gill-rakers long and slender, 29 on the first arch, 22 of which are on the lower limb.

Body compressed. The dorsal fin commences midway between the hinder edge of the eye and the root of the caudal; the length of its base is equal to the diameter of the eye, and its longest ray (the second) is one-fourth greater. The adipose fin is low, but very long, its base being greater than that of the rayed fin, from which it is separated by a space nearly equal to its own length. The anal is long, more than twice the length of the dorsal, and it lies entirely behind that fin; its longest rays are of similar height, and those of both fins gradually decrease backwards. The ventral is placed immediately beneath the anterior ray of the dorsal, and extends to the anal when adpressed. The length of the pectoral is equal to the longest dorsal ray. The caudal is forked, and the depth of its peduncle is less than the diameter of the eye.

Scales large, cycloid, and moderately adherent. There are about 25 in the longitudinal, and 5 or 6 in the transverse series.

The dark (steel-blue) colour of the dorsal surface is sharply defined from the silvery sides. The area surrounding the photophores is also very dark in colour.

Adopting the nomenclature applied to the *Myctophidæ*, the distribution of the photophores may be described as below:—Preorbital: 1, midway between the eye and the end of the snout. Suborbital: 1, behind the maxilla. Opercular: 2 on the opercle, and 6 beneath the gill-cover. Mandibular: 2 pairs on the mandible—1 near the symphysis, and the other much further back; 5 pairs on the isthmus. Thoracic: 5 pairs behind the opercle and parallel to its border, 12 pairs in advance of the ventral; also a series of 9 on each side, placed much higher and in the same horizontal line as the suborbital and lower opercular pores. Ventral: 6 pairs, the second one being below the level of the others. Anal: 25 pairs, a break between the 17th and 18th, occurring over the last anal ray; the anterior pore of the anal series is over the first anal ray, and placed high; the second pore is also higher than the following ones, which form an even and regular line. Caudal: none.

Length, 61 mm.

4. Centrolophus huttoni, sp. nov.

Mr. A. D. Goodall, of Kaikoura, recently advised me that he had caught a large sunfish, which was accompanied by a number of "pilots." He sent me two of the latter, and wrote as follows: "Respecting the sunfish, I noticed its back fin just awash with the water, and when it lay over on its side I steamed up and harpooned it. It must have weighed several hundred pounds, and was about 6 ft. long. I attempted to tow it home, but was compelled by heavy sea and head wind to cut it adrift. It was accompanied by about a dozen small bright-coloured (mauve is as near as I can describe it) fish from 8 in. to 15 in. long, which, for want of a better name. I called 'pilots.'"

I find the fishes to be examples of the genus *Centrolophus*, and they measure 381 mm. and 310 mm. in length respectively. I naturally turned to *C. maoricus* as the probable species, and also examined a large specimen taken at Sumner, near Christchurch, in 1903. This latter is preserved in the Canterbury Museum, and measures 783 mm. in length; it was described by Hutton and referred to *C. britannicus*.

In 1902 Regan reviewed the genus, and admitted three species—namely, *C. britannicus*, *C. niger*, and *C. maoricus*; he had not, however, seen examples of the last-named. Kolombatovic has since named a species *C. corcyrensis*,* but I am not able to consult the description. Leaving this out of the question, therefore, the distinguishing differences appear to be slight, and are expressed by Regan† in his synopsis of the species.

C. britannicus‡ is characterized by a larger number of rays in the dorsal and anal fins, and by the lateral line having a short curve above the pectoral.

C. niger§ and *C. maoricus*|| agree in respect of the fin-rays, also as regards the lateral line; the latter has the posterior half of the dorsal slightly emarginate, and has a somewhat shorter pectoral. It may be found that the two are not distinct.

The Kaikoura specimens substantially agree with *C. niger*, differing only in the smaller number of scales in the lateral line, and with this species I therefore identify them; and this leads me to think that the character of the dorsal rays in *C. maoricus* may have been an individual or accidental feature.

As already pointed out by Hutton,¶ the Sumner example is allied to *C. britannicus*; but for the present I propose to regard it as distinct, characterized by the much greater number of fin-rays, and by the long curve of the lateral line.

B. VII; D. X, 47; A. III, 35; V. 1, 5; P. 19; C. 15 + 8. L. lat. 240; L. tr. 23 + 60.

Length of head, 5·2; height of body, 4·8 in the length; diameter of eye, 4·6; interorbital space equal to the length of the snout and 3·9 in the head: nostrils confluent, without septum, the orifice with a narrow rod-like vertical bar; the cavity is close to the end of the snout, and separated from the eye by a space equal to two-thirds its diameter: the maxilla reaches to the front margin of the eye; teeth small, in a single series, very regularly disposed. Gills 4, a slit behind the fourth; gill-rakers moderate in length, and thick, 5 on the upper and 12 on the lower limb of the first arch. No pseudobranchiæ.

The dorsal fin arises above the root of the pectoral, and the length of its base is 1·2 in the total; the spines are very low, increase regularly in

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* Kolombatovic, Glasnik Naravosl., druzt. xiii, p. 30 (*fide* Zool. Rec. 1902, Pisces, p. 33).

† Regan, Ann. Mag. Nat. Hist. (7), x, 1902, p. 194.

‡ Günther, Ann. Mag. Nat. Hist. (3), vi, 1860, p. 46.

§ Gmelin, Syst. Nat., ed. xiii, 1789, p. 1321.

|| Ogilby, Rec. Aust. Mus., ii, 1893, p. 64.

¶ Hutton, Trans. N.Z. Inst., xxxvi, 1904, p. 149.

length, and merge into the rays; beyond the middle of the fin the rays decrease in length, and the fin terminates about two eye-diameters in advance of the caudal. The anal arises a little posterior to the middle of the dorsal, and its base is somewhat more than half the basal length of that fin. The ventral is very short (perhaps a character of the adult), being but an eye-diameter in length. The length of the pectoral is half that of the head. Caudal large and deeply forked, the peduncle compressed, its depth less than a third the length of the head.

The scales are cycloid, very small, and rather deciduous, leaving well-marked pits. Opercles scaly, the rest of the head closely beset with pores. All the fins scaly, the greater part of the dorsal and anal being thus covered. The lateral line forms a low arch over the pectoral, and with a less-marked curve joins the straight portion over the origin of the anal.

Colour faded.

Length, 776 mm.

The features of the four forms may, adopting Mr. Regan's synopsis, be expressed as follows:—

- *a.* Lateral line with a short curve. D. 45; A. 30 .. .. *C. britannicus.*
- *aa.* Lateral line with a rather long curve.
  - *b.* D. 37–41; A. 23–25.
    - *c.* Dorsal fin rounded .. .. *C. niger*
    - *cc.* Dorsal fin slightly emarginate in its posterior half .. *C. maoricus.*
  - *bb.* D. 57; A. 38 .. .. *C. huttoni.*

5. Cheimarrichthys fosteri, Haast. Plate XXXVIII, fig. 2.

Last year Mr. Edgar F. Stead brought to me a small fresh-water fish which, though he is an ardent angler, was unknown to him. I found it to be an example of *Cheimarrichthys fosteri*, described by Dr. Haast in a paper presented to this Institute in 1874. The original specimens were taken in the Otira River, on the western slopes of the dividing-range, "where that alpine torrent leaves its picturesque gorge"; hence the generic name, signifying "torrent-fish." Mr. Stead obtained his example in the Rakaia, an eastern river, and I have since accompanied him to the scene of his capture, for the purpose of obtaining some idea of the habits of the fish.

After arriving near the mouth of the Rakaia River we waded several streams alternating with flax (*Phormium*), cabbage-trees (and toitoi), and reached an arm of the river. By means of a punt and some strenuous pulling we landed on the further side; but another branch had to be crossed, thigh-deep, by wading. The rushing water was, however, safely negotiated, and here, in a veritable torrent, the fishes were said to live.

A small net, used after the manner of a seine and weighted with a length of chain, was the instrument of capture. So strong was the rush of water over the boulders that the net could not be used against the stream, and the opposite course was perforce adopted. At the time of our visit the water was so cloudy that nothing could be seen in it, but on successive hauls of the net several specimens of the fish were obtained.

A notice in the local Press brought me further examples from other eastern rivers—namely, the Ashley and Hurunui; and I was also told that they were known as "shark bullies," in allusion to the inferior position of the mouth, coupled with some resemblance to the gobies, commonly called "bullies."

The general conformation of the fish reminds one of a ground-shark, the under-surface being remarkably flat, apparently to enable the fish to keep close to the bottom, heading up-stream. The ventral fins are large and muscular, and may, indeed, be used for clasping stones; while the tail as would naturally be expected in a fish living in rushing waters, is large and powerful. The pectoral, also, has its longest rays in the lower half of the fin.

As above noted, Haast bestowed the name *Cheimarrichthys* in 1871. In the same year Sauvage used the form *Chimarrichthys* for an Indian Siluroid. This latter being of actual later date was superseded by *Euchiloglanis*, given by Regan in 1907.

Neither the original description nor figure of *C. fosteri* appear to be quite accurate: for example, the number of dorsal spines is stated to be 3, whereas 4, the correct number, are shown in the illustration; the pectoral and ventral are shown too far apart; and the very peculiar colour-markings are not hinted at, either in the description or figure. Under these circumstances, the following description and accompanying figure will be useful.

Haast placed the genus *Cheimarrichthys* under the *Trachinidæ* as then constituted, but recently Boulenger[*] has studied the somewhat heterogeneous assemblage, and has so narrowed the family down that it includes the single genus *Trachinus* only, which differs fundamentally, however, only by having the second suborbital produced in an internal lamina supporting the globe of the eye. *Cheimarrichthys* does not possess this subocular lamina, and Boulenger associates it with *Leptoscopus* and other genera to form the family *Leptoscopidæ*. To the osteological characters already ascertained I may mention that the vertebræ number 33.

CHEIMARRICHTHYS.

Family *Leptoscopidæ*. Scapular foramen wholly in the hypercoracoid; pterygials well developed, separate; no subocular lamina; ventrals jugular; head and body anteriorly depressed; tail compressed; mouth moderate. slightly oblique; the upper jaw overhanging the lower; teeth villiform, in the jaws and on the vomer; eyes supero-lateral; dorsal fin subcontinuous, the spinous portion short and low; head naked; body with ctenoid scales, lateral line nearly straight; gill-membranes free from the isthmus.

Cheimarrichthys fosteri, Haast.

Trans. N.Z. Inst., vi, 1874, p. 103, pl. xviii.

B. VII; D. IV, 20; A. 11; V. I, 5; P. 15; C. 12 + x; L. lat. 50; L. tr. circ. 10–10.

Length of head, 3·7; height of body, 4·3 (or rather less than the width of the head); length of caudal, 4·5 in the total; diameter of eye, 5; length of snout, 2·2; interorbital space, 6·5 in the head.

The head is very broad and markedly depressed, the lower surface flat; the interorbital space is flat, and in profile forms an obtuse angle with the snout; the eyes cut the profile, and are directed as much upwards as laterally; the nostrils, two on each side, are large round openings with fleshy rims, the rim being highest behind on the anterior pore, and highest in front on the posterior one; they lie close together, a short distance in front of the eye, and each pair is separated from its fellow by a space equal to the interorbital; the mouth is moderate, non-protractile, with large fleshy lips; the maxillary, which can be almost wholly concealed by the premaxillary and suborbital, does not extend to beneath the anterior border of the eye. Gill-openings wide; gills 4, a slit behind the fourth; gill-rakers rather short, 9 in number, on the first arch, 7 being on the lower limb.

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[*] Boulenger, Ann. Mag. Nat. Hist. (7), viii, 1901, p. 261.

The dorsal fin arises behind the insertion of the pectorals; the 4 spines are very low, lengthening slightly backwards, but the last one is only half the diameter of the eye; the rays are long anteriorly, and decrease regularly, the last being equal to the length of the eye; the third ray is the longest, being two-thirds the length of the head. The anal originates beneath the seventh ray of the dorsal, and terminates very slightly in advance of the end of that fin; the rays are thickened, and free at their tips. The pectoral is triangular, its lower edge rounded; counting from above, the twelfth ray is the longest, and is nearly as long as the head; all are divided. The ventral is very large and muscular, with a broad insertion; it does not reach the vent. The caudal is slightly emarginate, its peduncle deep, being 2·2 in the head.

Scales.—The head is naked; the space from the occiput to the anterior dorsal rays down to the origin of the lateral line is covered with extremely small scales; the lower surface of the body backward to the origin of the anal, and including the area around the lower base of the pectoral fin, covered with similar scales; the larger scales, which occupy the rest of the body, are finely ctenoid; the free portion of the individual scale is scallop-shaped, and its inserted edge is rectangular and truncate, the caudal scales being longer than those of the body; the lateral line runs almost straight from the opercle to the middle of the caudal; the tubes are quite horizontal.

Colours.—Greyish-olive above, sides yellowish, lips and under-surface delicate pink (white in preservative). Three dark-grey broad oblique bars descend from the back forward, but do not reach the ventral surface; they are darkest behind, and are evenly graduated, the hinder edge being black and sharply defined; this edge is succeeded by a white line, which gives place to yellow, then to brown, forming the bar described. The hinder edge of the first bar passes from beneath the middle of the dorsal rays in a line towards the vent; that of the the second from beneath the last dorsal ray towards the middle of the anal; the hinder edge of the third bar is more nearly vertical, and passes across the upper base of the tail. The markings of all the fins form lines, due to spots on the rays; there are about 4 lines on the dorsal, 5 on the pectoral, and 3 broken rows on the ventral, the inner ray being unspotted. The anal has a single row of dark intramarginal spots; the caudal bears 5 rows, the anterior one being especially characteristic, forming a 3-shaped figure, with the central projection directed forward. The markings on the head are not well defined; but a bar between the eyes and a V-shaped mark below the eye may be traced in some examples.

Length of specimen, 112 mm.

EXPLANATION OF PLATES XXXVII AND XXXVIII.

Plate XXXVII.

Centrophorus plunketi.

Plate XXXVIII.

Fig. 1. *Triarcus australis.*

Fig. 2. *Cheimarrichthys fosteri.*

ART. XLIX.—*The Pipiwharauroa, or Bronze Cuckoo* (Chalcococcyx lucidus), *and an Account of its Habits.*

BY ROBERT FULTON, M.D.

[*Read before the Otago Institute, 8th June,* 1909.]

THE bronze cuckoo is probably a native of New Guinea, and annually migrates to New Zealand, passing through or near New Caledonia, the Kermadecs, Norfolk Island, and, striking the coast from the western ocean, traverses the islands, and even goes further on, appearing at the Chatham and the Macquarie Islands (1) a day or so later, thus forming an additional link in the large chain of evidence as to the original land-connection of the various islands forming what is known as the New Zealand plateau. That the birds come over the ocean from the north-west I will present evidence later on; but I would like to point out that they have been recorded at Lord Howe Island. After sojourning with us for a few months, and producing a considerable number of young ones, these summer visitors quietly return to their home in the tropics.

To the Maoris the cuckoos have been known as "the birds of Hawaiki," and even the name "pipiwharauroa" is used alike for the bronze cuckoo and for the constellation of the ark or canoe (2)—a distinct evidence that at one time it was known to the Natives to have some dim connection with those far-off lands from which their first canoes came. The meaning of the name has puzzled me, and I have several suggestions to put forward on this point. A derivation that seems possible to me is "pipirau whawharua" —*pipirau* means "some portion of the spirit-world," and *whawharua* "a mother or ancestress"—that is to say, this curious cuckoo is a bird whose mother we know nothing about, but who we think comes from some portion of the spirit-world. The word "pipi" is used for the large cockleshell, then for the two halves separate, then for a double canoe: "the mother or ancestress who came in the double canoe." I need not multiply instances, but I hope that some of our Maori scholars will look up this point, and make quite clear whether the name came with the Maoris from some far-away islands, or whether it is a comparatively new name formed from some word or words having reference to the habits of the bird.

Another name for the bird is "whenakonako." *Whenako* is a robber, and *nako* is to dig or scratch (2). This may mean "the robber who digs his way into the earth," or merely "robber," with a repetition of the last two syllables. The Maoris were well acquainted with the bird, with its curious appearance and disappearance, its evidence of early spring-time, and its detestable habit of inflicting its young upon other birds; but it is strange that, so far as I can gather, they have not put on record any observations of its destruction of its foster-brothers or sisters, though this could hardly escape the notice of such keen students of nature. The bronze cuckoo was first described by Forster (1) in 1872, who called it *Cuculus nitens*, the glistening cuckoo, or the poupouarouro of the Natives. Gmelin (1) called it *Cuculus lucidus* in 1790; Lesson altered the name to *Chalcites lucidus*; Gray, from Dieffenbach's specimens, used the name *Chrysococcyx lucidus*, and this name was used until the last ten years, when the present name *Chalcococcyx lucidus* was adopted by modern naturalists.

The Rev. William Yate (4), in his "Account of New Zealand," published in 1835, makes the remarkable mistake of confusing the two cuckoos, for he says, "The kohapiroa is one of the sweetest songsters of the woods, but is only heard for about four months in the height of summer. It secures itself during the winter months among stones, or in the holes in the puriri-tree, and does not leave its retreat until all danger of being overtaken with cold has passed away. The pipiwawaroa is a bird of passage, supposed to come from the islands north of New Zealand; but the Natives assure us that it retires in winter into holes in trees or crevices in the rocks, and does not fly away into winter quarters in other and warmer climes. It is a small bird of very beautiful plumage; green, white, purple, and gold are the prevailing colours. It has no song, is easily caught, and feeds upon the small insects found upon the kauri-tree."

Polack (5), who visited New Zealand, and published in 1839 his "Travels and Adventures in New Zealand," says, "Parasitic cuckoos are also found with various plumage, many of them entirely black in an atramentous covering, others variegated in green, white, and yellow; some may be seen beautifully attired in golden-green annulets mixed with black, adding a richness to the verdant green common to the birds of Java." A great deal of what Polack has written is incorrect, as was that of the Rev. William Yate, to whom I have referred. Polack says of the kohapiroa, "This little fellow is remarkable for taking particular care of itself, never leaving its retreat until the cold winds from the south have ceased to blow. It fills the bushes with melodious notes, only equalled by musical bells."

Little reliance can be placed upon the information of these two writers, who were, so far as our birds are concerned, no observers; but when we come to Dieffenbach's "Travels in New Zealand" (6) in 1843 we have the work of a true naturalist. His terse description of the birds, and Gray's classification, are all that can be desired; but he is evidently puzzled by some of Yate's inaccuracies.

The Rev. Mr. Taylor (7), in 1870, published his "Te Ika a Maui," and informs us as follows: "The piwarauroa (*Chrysococcyx lucidus*) is the other cuckoo, which is also a bird of passage. Its breast is white, the feathers being fringed with green and gold; the back is green, gold, and bronze; the feathers under the tail are white, spotted with brown. It has a very peculiar shrill note, but when first heard in August its cry is feeble. There is a saying that if it continues to cry 'kui, kui,'' it will be a cold summer; but if it sings 'witi, witi, ora,'' it will be a warm season."

Hutton's "Catalogue of the Birds of New Zealand," (8) published in 1871, describes the whistler, or pipiuwaroa, gives careful measurements, and says, "Migratory. Leaves New Zealand in the winter, and is found in Australia, Tasmania, New Caledonia, Java, and Sumatra." Three years later Buller (9) published his first edition of his "History of the Birds of New Zealand," and evidently copied Hutton's description of the bronze cuckoo, as his wording is identical. His "Manual of the Birds of New Zealand" came out in 1882, but that and later publications threw no fresh light on the subject, and it was not until 1904, when Hutton and Drummond's "Animals of New Zealand" appeared (10), that any new details as to the economy of this bird were made available. Among many interesting points in this book is the statement that the bronze cuckoo is found in New Zealand, Norfolk Island, Cape York Peninsula; but that in this habitat it is rare. If you turn to Campbell's "Nests and Eggs of Australian Birds" (11), published in 1900, you will find the habitat for *Chalcococcyx lucidus* extends down the east of Australia to Tasmania and New Zealand. One correspondent who lived for many years in north Taranaki, and knew the bird well, and had, in fact, for years noted the dates of its arrival, writing from Perth, Western Australia, says that "the bird was very common there in December, 1908, especially on the Darling Ranges, on the west coast" (12).

In Australia it is called the "broad-billed bronze cuckoo," to distinguish it from the "narrow-billed" (*Chalcococcyx basalis*) and the "bronze" (*C. plagosus*). Campbell (13) confines our bird to the habitat mentioned, and does not say that it is considered migratory to the tropical regions; but when he speaks of *C. plagosus*, the one most closely allied to our bird, he mentions that it is found in southern New Guinea and the adjacent islands right up to the Solomon Archipelago. The narrow-billed (*C. basalis*) has also a range right up to Timor, Java, and Malacca; so that it is extremely probable, though not yet determined, that our bird (*C. lucidus*) also comes from some place to the north of Australia, probably New Guinea. It is much more likely that the birds come from a large continent like New Guinea than from some scattered islands in the Pacific; and the fact that the bird has the Australian range before mentioned entirely disposes of the idea that New Caledonia is its wintering-place. New Caledonia may be a stopping-place, but there is no doubt in my mind that New Guinea will be found to be their home, and that the two land-bridges—one down through New Caledonia, Kermadecs, Norfolk Island, to New Zealand and the Chathams; the other down northern and eastern Australia to Tasmania—satisfactorily account for their presence in Australia and New Zealand.

It is quite possible that the Australian individuals are stragglers who have been blown a little to the west at the time of starting from New Guinea, have struck the coast of Australia, and have come straight on down Cape York Peninsula, instead of winging their way on towards New Caledonia. It is curious and most interesting that *C. plagosus*, which does not reach us here, but is very common throughout Australia, is occasionally found in New Caledonia; and the same explanation accounts for that. The birds have in that case started off a little too far to the east, have flown on as far as New Caledonia, but, having no land-bridge memory to bring them on to New Zealand, have remained there. The flight from New Guinea to New Caledonia is quite as long as anything they have ever made to Australia, and quite enough to satisfy their migratory instinct. Our own birds, however, accustomed to a much longer journey, wing their way right on to our islands, rarely even stopping at New Caledonia.

I have seen it mentioned somewhere, but cannot lay my hands on the reference, that migratory birds of the passerine order have been frequently seen to rest on the water on fine smooth days, and in this way the terrific strain of the journey may be lessened. In a recent number of the *Ibis* (14) I read of a tremendous flight of swallows and other birds clustering and resting on one of the big P. and O. liners on her way through the Red Sea. This is a most curious circumstance, seeing that there is land on both sides, and the birds had been really flying over land for some hundreds of miles. The migratory instinct, which seems to us most strange, is in the adult bird caused by the need for getting from one place where food is becoming scarce to another where the climate is warmer or more suitable for the upbringing of young, and food is more easily attainable at that time of the year. This, with the inherited memory of past flights to a suitable locality, accounts for the action of the adult birds; but what a mystery is before our eyes when we think of the young, newly fledged birds leaving this country and starting to wing their way back to New Guinea—unguided by their parents, who have left before them—accompanied only by a number of young birds as ignorant as themselves of the locality of the winter home in the tropics! Still more mysterious is this when we read of a young cuckoo, kept in a state of captivity, and prevented from migrating at the proper season, entranced, as it were, in an instinct of migrating, keeping up for hours an apparent flight over a trackless ocean.

Benjamin Kidd (15) says of the English cuckoo, "Some years ago I had the good fortune to rear from the beginning a specimen of the young of the common cuckoo. As my young cuckoo became full grown it was gradually attuned by nature for its wonderful migratory flight. The cuckoo travels in its annual migrations enormous distances over land and sea, sometimes from the extreme north of Europe across the Equator into the Southern Hemisphere. In this case there is no room for thinking that the young birds find their way as the result of any teaching from the older birds of the kind, for these leave many weeks later than the older birds, and so travel apart. As the season waned, and the time for the migration of my young cuckoo approached and passed, its behaviour grew interesting. The bird always became very restless in the evening. Being much attached to me, it generally settled at last, so as to be near me, on the stationery-case on the table on which I was writing, in the dim light thrown by the upper surface of the green shade of the reading-lamp by which I worked. Here, as the hours wore on, the same thing happened every night. After a short interval the muscles of the wings began to quiver, this action being to all appearance involuntary. The movement gradually increased, the bird otherwise remaining quite still, until it grew to a noiseless but rapid fanning motion of the kind that one sees in a moth when drying its wings on emerging from the chrysalis. This movement tended to grow both in degree and intensity, and it generally lasted as long as I sat up during the night. In the early stages of this mood the bird responded when I spoke to it, but in time it ceased to do so, and became lost in a kind of trance, with eyes open and wings ceaselessly moving. Brain, muscles, nervous system, and will all seemed to be inhibited by the stimulus that excited it. The bird became, as it were, locked in the passion of that sense by which the movement of flying was thus stimulated. It was one of the strangest sights I had ever witnessed—this young migratory creature of the air, which had never been out of my house, and which had never known any of its kind, sitting beside me in the gloom of our northern winter and in the dim lamplight, by a kind of inherited imagination, yet which was not imagination in our sense, flying thus through the night league-long over lands and oceans it had never seen." It would be of extreme interest if some of our naturalists would capture and retain some of our young cuckoos of each species and endeavour to determine whether the same thing would occur here.

Richard Kearton (16), the well-known writer on birds and their nests, says, "The speed and endurance of some species is remarkable. It is asserted that both the common swift and the Virginian plover can travel well over two hundred miles an hour, and the former bird is on its untiring wings sixteen hours a day. The performances of our "ocean greyhounds," which have an unlimited amount of coal and water, are paltry in the extreme when compared with those of a bird which could easily fly from

London to New York during the light of a single day, on a mere thimbleful of gnats, or one that can take its breakfast in Canada and its supper in Brazil. Sustained powers of flight are chiefly useful to the majority of birds during their migratory journeys. On these occasions they perform some astonishing feats, principally during the night-time, when I have heard different species calling to each other as they passed over London. The migratory movements of birds are in many respects very curious indeed: all breeding movements are in the direction of the Poles and away from the Equator. These great spring and autumn movements take place over certain well-established tracks or "fly-lines," and the mystery of mysteries is that during the autumn journey the birds that know nothing about the fly-lines from actual experience go first. Out of three hundred and sixty different kinds making the Island of Heligoland their stopping-place for a rest, in only one single instance do the old birds precede the young ones, and that is the case of the cuckoo. Migrants from Europe spend the winter in Africa as a rule, and it is said that those breeding farthest north in the summer fly farthest south in the winter, and that British swallows and martins reach Natal and Cape Colony."

Chalcococcyx lucidus has a number of popular names the bronze-winged, shining, glistening, bronze, golden-winged, green, short-tailed, and smaller cuckoo; cuckoo's mate and dog-whistler, or simply whistler, are also common terms based on its curious cry. The bronze cuckoo may be said to be one of the most notable of the New Zealand birds, and to have a real historical and geographical value, for it was by observing the habits of the bird that naturalists found that New Zealand participated in the great southern migrations. When Mr. Colenso (17) stated in 1812 that this bird was migratory, the furthest distance across the sea that migratory birds had been known to fly was from Norway to Scotland, and across the eastern Mediterranean Sea from Egypt to the Greek Islands in each case a distance of about three hundred miles, involving about eleven hours' continuous flying. When it was asserted that the shining cuckoo traversed more than three times that distance of ocean—from New Caledonia to New Zealand and the Chatham Islands– it was thought that naturalists here had made a mistake. A. R. Wallace, in his "Geographical Distribution of Animals," as late as 1876 says, "This is extremely improbable, especially in a country which has still such wide tracts of unsettled land. It is very possible that the birds in question may only move from one part of the islands to the other." Hutton and Drummond add, "It is now fully acknowledged, however, that those birds do migrate, and that they are among the most notable migratory birds in the world."

Early in spring, usually about the last week in September, residents of New Zealand from end to end are familiar with the beautifully sustained notes "kui, kui, kui" of our bronze visitor. For a week or two the "whiti whiti, ora," or the final flourish or trill of "tiu, tiu, tiu," is not heard; and, just as in England the first notes of the common cuckoo are not what they are a few weeks later, so in New Zealand and Australia (18) the first arrivals, the males, are either silent or their song or call is decidedly shorter and more limited than when the breeding season is in full swing and their notes of courtship are more entrancing. Bearing on this question of the shortness of song of the first arrivals, the male birds, no doubt, as is well known of migratory birds, having the lead on account of strength of wing, Mr. Campbell says of the pallid cuckoo, "They are first heard about the end of August or beginning of September, but so far as my observations go these are preceded by silent birds of the same species, which may be seen about the timber, or perched on fences or telegraph wires, about the first week in August. Why these forerunners should be silent, or whether they are all of one sex, has not been ascertained." A number of our New Zealand correspondents confirm this limitation of the call of our bird in the first few weeks of its arrival.

In good and warm seasons the birds probably come a little earlier, and the females arrive on a correspondingly early date. This, of course, accounts for the early production of the full note or song, "kui, kui, kui, whiti, whiti, ora," in a good and possibly apparently mild season, a point in the economy of the bird which the Maori was quick to notice (19).

Herr Gatke (20), one of the greatest authorities on migration of birds, says that the forerunners of the spring migration in the Northern Hemisphere are invariably old males; next come the adult females; then younger males and females; and finally males and females of the previous year. Supposing these cuckoos all start at about the same time, the strongest birds would obtain a lead by the stream of birds tailing out on a journey of this length, and the males, on arrival, would be comparatively quiet until the arrival of the females. There is no doubt that the birds take advantage of favourable winds, and wait till a favourable wind blows, or their instinct may have been adapted in the course of ages to the exact period of the year on which a particular wind blows. The gales of certain directions in the Southern Pacific are all fairly punctual, so to speak, and are generally on hand when expected. The birds come down from the north-west, and strike the coast-line of New Zealand in great numbers, for evidence is forthcoming that they are heard almost as early in the south of Otago as in the north of Auckland, and the dates on which they are stated as being seen and heard throughout the islands do not connect or coincide in a manner sufficient to prove to us that the birds reach the far north first and gradually work south, though this is, of course, possible. When we know that these birds must easily cover five hundred miles a day, it is not of much consequence to know what day in September or October they arrive at any one particular part of the Dominion. They have been heard as early as the 7th September in north Taranaki, and at Tongaporutu, forty miles north of New Plymouth, on the 28th September. They have been heard as early as the 15th September in Otago, and for many years I noted their arrival at West Taieri from the 20th to the 23rd. Reports come from many other places during the same week, and they keep on arriving and being reported as late as the end of October or even into November. In quite a number of instances the lighthouse-keepers, to whom I specially appealed four or five years ago, have reported the arrival of the birds, noting barometer and thermometer and direction of the wind at the time, and almost invariably the wind is strong from the north-west. Mr. Anderson, at Kahurangi Point Lighthouse, which is half-way between Westport and Cape Farewell, says, "One arrived on the 6th October; on the 13th I saw three."

The birds are reported to have been seen in great numbers at Totara, an old Maori battlefield two miles south of Shortland, Thames. Mr. Noel Buchanan reports it at Collingwood on the 25th September; Mr. Elsdon Best at Ruatoki on the 2nd October; Mr. Puckey at Kaitaia on the 6th October; and Mr. McCulloch at Hastings on the 12th October.

Mr. Arnold, from the East Cape Lighthouse, says, "On the night of the 5th November one bronze cuckoo struck and killed itself against the lanternpanes of the lighthouse"; and during the next day he noticed one flying about the island. It allowed him to get within a few yards of it, so he supposed it was pretty well exhausted. The wind for the previous week had been from the westward, blowing strong. This bird had come on, and almost overshot the island during the night by mistake, or possibly was one of those which had previously migrated to the extreme eastern portion of the New Zealand plateau—namely, the Chatham Islands—for which it was directly heading.

These references make it fairly clear that the birds arrive in considerable numbers by a north-west or westerly wind about the latter end of September, and, striking the coast, spread all over the Dominion and on to the outlying islands in a few days, or even possibly hours. They keep on arriving for several weeks, and, though often seen, are not heard for some days after their advent. On the outlying parts of the coast they are seen in greater numbers, as these are principal ports of arrival from which the birds spread out over the country.

The birds soon begin their beautiful call of "kui, kui," generally at night at first, and whether the full song is uttered by the male bird or female, or both, has not yet been determined. It is possible that the incomplete song is that of the male, and the beautiful twittering call with the flourish at the end the female's. This interesting point can only be cleared up by getting specimens of these birds during their call.

It is quite certain that, whether due to losses on the voyage or for some other reason not yet understood, the females are always in a considerable minority, and that the bronze cuckoo, like parasitic cuckoos and cowbirds elsewhere, is polyandrous, and the ventriloquistic whistle which is characteristic of birds of similar habits all the world over is part of the complicated scheme of parasitism (22). Those who are interested in this question will also find it fully set out and explained in my papers on the long-tailed cuckoo (21).

With regard to the whistle, I have been standing under a manuka-bush, and have heard the bronze cuckoo whistling "kui, kui, kui," and have located it to my satisfaction to be calling from the top of a white-pine 50 to 100 yards away, and, say, 100 ft. up in the air; then I have changed my opinion when the second silvery bar began and progressed; then another set of notes, and I have decided that the bird was in a big broadleaf-tree, say 50 ft. or more away; then a fresh set of "kui," and I have begun to wonder if the bird was not in the very bush under which I was standing; and finally, with the notes welling out into a piercing call, I have found it within 5 ft. or 6 ft. of my head, shaking and twittering, with its quivering wings half-spread, expressive, as Buller says, "of a state of highest ecstacy." Now when I hear a cuckoo calling I stand perfectly still and search the closest boughs with extreme care, and then I can generally see the bird calling quietly and softly, and can almost detect the extra power and force it puts into its notes by its gradually increasing movement, and I might almost say increasing chest-expansion. The bird seems actually to swell itself out much in the way the tui does when he is showing off for the benefit of his white-throated consort. This cuckoo's call is one of the most perfect examples of ventriloquism, and the harsh cry of the koekoea is thrown out in the same extraordinary manner.

Touching on the question of polyandry, one correspondent says, "On the 13th October I saw three in a young rata-tree; one was sitting with its wings spread, the other two were chasing each other through the branches."

This was undoubtedly a female bird with two male birds. Exactly the same description almost to a word is recorded elsewhere, and has been frequently given to me about the long-tailed cuckoo. "On one occasion I saw about five or six; they seemed to be fighting, for they flew close past me. As it was the early season, they were probably males fighting for a mate." [*Otago Witness.*]

There is another point with regard to the call that must be noted, and that is the extraordinary effect it has upon the other birds in the neighbourhood. As soon as the call begins anywhere near a spot where sparrows and linnets abound, a chattering and screaming at once is set up, and all the birds in the vicinity congregate and hunt the intruder. The tomtit and fantail seem to be very much afraid of the cuckoo, and usually retire hastily on hearing its cry. A bronze cuckoo has been seen to go into a willow-tree in which was a nest of the grey warbler, and the two little birds stayed close to the nest absolutely still, as if paralysed with fear, or fascinated. The cuckoo flitted about a little, and then flew away, without molesting them or their nest.

Sometimes the pipiwharauroa is seen on the topmost branch of a high tree, and when it gives forth its note it is at once hunted from its perch by tuis and mockers. If it flies away and alights on the highest limb of some other high tree—generally a leafless limb—it is again hunted off by the tui. Mr. Mahoney, Native teacher at Hiruharama, Waiapu County, Hawke's Bay, says he has heard the bird call, and on running to the window has seen it fly away, leaving the sparrows, minahs, yellow-hammers, and thrushes discussing his sudden appearance in very excited and indignant tones.

The kingfisher is an enemy, and has been seen chasing the cuckoo from tree to tree. It may be taken for granted that this hostility is due as much to the bird's thieving propensities as to its habit of entrusting the hatching of its progeny in many instances to other birds. The long-tailed cuckoo (22) was similarly charged, and most ornithologists discredited the idea of its predatory habits, and said that the hostility of other birds was due to the fear of having their nests burdened with a parasite which would soon destroy the rightful tenants. Sir Alfred Newton and many others considered the accounts of cuckoos being found with eggs in heir bills was no proof of stealing—that the whole story was a vulgar error, and that in all cases the egg was that of the cuckoo herself. Those of you who have read my papers on the long-tailed cuckoo know how I disproved that theory, and showed what the bird does in the way of egg and chick stealing in New Zealand (23). Similarly, the few instances I give you about the bronze cuckoo show that it also takes eggs from little birds' nests, but it is not likely that it takes chicks, as its size and structure are not suitable for tearing up little birds, as does the koekoea, nor is its throat large enough to swallow unfledged chicks whole, as that rapacious creature does.

One correspondent whose letter I have mislaid saw a bronze cuckoo in the garden with a blue egg in its claw, and it was pecking at it and eating it. Basil Henning, of Akaroa, gives a thoroughly clear account of the same thing. He says, "I wanted a bronze cuckoo for my collection, and, while waiting hidden, the bird came down to the brown wren's nest, in which were four eggs. It entered the nest and flew off with one egg. When I killed the bird the egg was broken. I am certain the bird intended to eat the egg, and the egg taken out was the brown wren's—*i.e.*, brown creeper—and exactly the same as the other eggs in the nest." These two instances, with the evidence of what we know of other cuckoos, make it certain that *Chalcococcyx lucidus* is predatory. Mr. Potts (24) says, "The whistler is a great insect-eater, and appears specially fond of the well-known ladybird. We are not without certain suspicions that it devours or destroys the eggs of other birds."

Now, as to the other reason for the hatred of the birds generally the habit of coolly dropping its eggs into other birds' nests of this the evidence is overwhelming, though no one has as yet seen the act of deposition. The riroriro (*Pseudo-gerygone*) has been known to actually hatch out this bird from an egg which has been dropped into its little bag-like nest ; and the monster thus hatched in many instances heaves out the occupants, or lies on top of them, so as to obtain possession of all food and thus starve them. I have myself found young warblers alive on the ground beneath the nest containing a young bronze cuckoo ; I have replaced the young warblers, and found them dead on the ground next day. I also remember as a very small boy being told that one of my brothers, now deceased, had actually seen the process of expulsion going on, but I was too young to take any interest in it. Now, why is the grey warbler the bird that is most frequently selected as a host for this egg—the only bird in our country which builds a domed or covered-in nest ? Many of you know Wallace's description (25) of the feeding-area and the breeding-area of migratory birds. Now, in some birds the summer breeding-area and the winter feeding-areas coincide -the nature of the country is satisfactory, and the supply of food is available all the year round; in others the two areas are separated by more or less wide intervals. New Zealand is the breeding-area, New Guinea probably the feeding-area, of this cuckoo, and the construction of the nest of the riroriro leaves no doubt that it, too, in the remote past, came to this end of the great continent to breed, still building its pendant nest, so difficult of access to the various enemies—snakes, &c.—which it had to face in its tropical feeding-area. In all tropical climates there are numbers of birds which build pensile nests, adequately protecting their young, and it is significant that the only other one of our birds which has a nest approaching in any degree a pensile nature is the white-eye or *Zosterops* of tropical Australia. The cuckoo chooses the nest of the warbler—first, because it is a bird that almost certainly at one time had the same breeding and feeding areas ; second, because the young hatched in such a pensile nest have more chance of reaching maturity than when hatched elsewhere—eggs deposited in such a nest are in comparative darkness, and are less likely to be disturbed, thrown out, or deserted. Chicks reared in such a warm, comfortable home have a great advantage over birds growing in open, uncovered nests. The proof of these points can be seen in the preservation of the riroriro when so many of our other little birds have almost disappeared. Sir Walter Buller (26) gives an account of the warbler hatching out a young cuckoo, and has a plate of the cuckoo in a warbler's nest; and Potts (24) mentions sixteen instances of cuckoos' eggs taken from the nest of the warbler.

A correspondent had this season a cuckoo's egg and several eggs of the warbler sent him through Magister's kind offices. These had been most unfortunately removed from the nest instead of being watched for further developments. There is no doubt that a number of young cuckoos of either species are fed by other birds, and particularly by the grey warblers, which have not necessarily hatched them at all, but which, finding them piping in distress, take pity on and feed the orphans. This is quite commonly observed in Australia (22). Little birds which are never known to hatch out cuckoos have been seen to feed young ones; not only so, but different species of birds have been seen to come to the same cuckoo and feed it one after the other. "During the months of October and November it is no uncommon sight to see the smaller Australian birds feeding the young cuckoos. Even the little *Acanthizæ*, which are seldom if ever the foster-parents of the pallid cuckoo, join in supplying the wants, which are made known by a peculiar peevish cry. It stops only while feeding is going on, or when the appetite is fully appeased." So the New Zealand birds the makomako, the tui, the warbler, the tomtit, robin, brown creeper, canary, the wood-pigeon, and the white-eye are all known to feed the cuckoo bantlings, not because they are purely duped, but very often from a true philornithic spirit. It is fairly certain that in those cases where the warblers have been seen to feed more than one cuckoo at a time the warbler was a foster-feeder only, and not a foster-parent.

"On February the 11th my son drew my attention to two young shining cuckoos sitting on a branch of a nut-tree being fed by two wrens (probably grey warblers). It was most interesting to see how assiduously they searched for insects for them, and popped them into the big birds' mouths almost quicker than your eye could take stock of the action. After about an hour one wren went away, and, so far as we can discover, never came back again, the feeding then devolving on the other bird; and as the day wore on she was bullied most unmercifully by the two cuckoos, who kept up a constant twittering, and chased her from tree to tree, pecking her if she did not bring them food quick enough. She soon had a dishevelled appearance from her exertions, and could be seen at odd moments trying to preen into order her dishevelled feathers, when down would swoop one or other of the cuckoos and peck at her till she hurriedly hopped or flittered from twig to twig, and, returning with lightning-like quickness, popped a minute insect into its open mouth. My family watched them being fed thus by one wren all that and the next two days, and they have been heard but not observed closely to-day. I thought this case was worth recording, as I was of opinion the cuckoo only laid one egg in each nest. It seems almost an impossibility for two such large birds to hatch out of so small a nest." No case has ever been recorded of two cuckoos of the same age coming to maturity in an adopted home; many cases, however, have been known in which two cuckoos' eggs have been hatched, deposited certainly by two different cuckoos. In such a case a continual struggle goes on for the first few days, ceasing only when the stronger or more adroit succeeds in hurling to destruction its companion. Similarly, when warblers with their own chicks have been seen feeding young cuckoos, they are not the foster-parents, but only foster-feeders.

The young birds are singularly helpless or lazy, as the following instance shows: "I first became acquainted with this bird in 1888. I was roaming about in the bush, and heard it piping as in distress, and discovered him being fed by little warblers. Later on I found some in a paddock of clover infested with caterpillars; the caterpillars were crawling over their feet, and yet they cried to the small birds to feed them, and so save themselves the labour."

A number of other birds are imposed upon—fantails (26), robins, tomtits, blackbirds (28), and sparrows (29), as eggs have been found in their nests. As is the case with cuckoos elsewhere, the egg varies considerably, according to the host imposed upon. The commonly accepted description of it is olive-green (29), but white eggs and blue eggs of a curious elongated shape have been found, which, there is no doubt in my mind, belong to this bird. One gentleman says, "Last year while clearing bush I accidentally cut down a tree containing the nest of a riroriro. On examination I found snugly stowed among the feathers with which the nest was profusely lined, three eggs. Two of these were roundish, plump little eggs of a dull-white ground with brown spots; the other a long, narrow, blue egg, not bulging in the middle, but gradually tapering from end to end, as if intended to be carried in the beak of the cuckoo, and so placed in the nest. Of course, I could not say they actually do this, but it is the only way to account for its presence in the nest, the aperture being far too small to admit either of the New Zealand cuckoos without destroying the whole fabric."

I need not go into the question of the variability of cuckoos' eggs: it is well known, and has been discussed for the last fifty years. I need only say that particular birds have selected particular hosts for generations, and the eggs in these cases have gradually become approximated in size, coloration, and spotting to the eggs of the nest-owner. How the egg of the shining cuckoo is placed in the nest of the warbler is as yet unknown; the cuckoo almost certainly lays the egg on the ground and then places it in the nest with its beak.

Mr. Jesse (31) refers to the fact that he has found the egg of the cuckoo in a nest where it is impossible for the bird to have deposited it other than by its bill. The fact of the cuckoo carrying her egg in her bill is now generally admitted (32). In Tasmania (33) a fresh egg of the fantail cuckoo was found deposited on a bare stump. Doubtless it had been laid there by the bird, which was probably disturbed before it could convey it away to some suitable nest.

There have been a few fortunate observers who have actually seen the deposition of the egg upon the ground by the cuckoo, who then, taking it in her bill, introduces it into the nest (34). The most positive evidence on this point is that of Adolph Muller, a forester at Gladenbach, in Darmstadt, who says that through a telescope he watched a cuckoo as she laid her egg on a bank, and then conveyed the egg in her bill to a wagtail's nest.

Having deposited the eggs in various nests, the adult cuckoos roam about in little flocks of five or six males to one female. They feed on flies, moths, ladybirds, and other insects, until their young ones are able to fly, keeping an eye on them, occasionally feeding them, and getting ready to shepherd them until the time for the return migration. This is quite commonly known and recorded, and I have referred fully to it in connection with the long-tailed cuckoo. Allan Hume (35) says, "I have never seen crows feeding fully fledged koels out of the nest, but I have repeatedly watched adult koels feeding young ones of their own species. I am pretty nearly convinced that after laying their eggs the females keep somewhere about the locality, and take charge of the young directly they can leave the nest; but I never saw more than one young one in the charge of an old female." Another correspondent says, "I once saw a young cuckoo which was being fed by two little grey warblers. Then I noticed another cuckoo on a branch not far off, and after a little while the little birds fed him also. They remained in the same bush all day, and did not mind when you came quite close up to them; they kept on feeding them till it was getting dark, and next morning I found them again in the same hedge. About 9 o'clock there appeared, to my surprise, a third cuckoo. It was bigger than the others, and seemed very wild. This one could feed itself already, because I noticed it picking things, probably leeches, from the leaves; but it still wanted to be fed by its foster-parents. I counted five warblers, one on the hedge and four feeding the three cuckoos. On the third morning they were still on the hedge, but about 10 o'clock they disappeared among the trees. When birdnesting I have found sparrows' nests with strange eggs in them, which I took to belong to the cuckoo."

A correspondent from Rotherham says, "We have had two shining cuckoos visiting our garden every day for the last week. The birds are, one a well-grown young bird, the other an old bird. Their favourite haunt is a pear-tree that has suffered rather much from the pear-slug, which they seem to enjoy. In the early morning the birds are to be seen among the fruit trees. The young one is very tame. I could have caught it with a butterfly-net on more than one occasion. I never knew an old bird to stay so late as this (21st February), even in Taranaki."

Another correspondent says, "I have often seen a pair of warblers feeding a young cuckoo in addition to their own offspring. I do not think the cuckoo throws the young warblers out of the nest, for I have often seen the parent warblers feeding one cuckoo—never more than one—and two young warblers. The parent cuckoos do not seem to eat much during their stay here—I have never seen them eat anything but an occasional butterfly."

A writer from North Taieri tells me that he saw some young cuckoos about the 1st February on a kowhai-tree. The down feathers were still there, though only a few to be seen. The plumage was nearly full, the green not showing, the copper predominating. Towards the middle of the month they had the first part of the adult cuckoo's notes, such as the adult has in the early part of the season. Some years ago he saw one or two very young birds being fed by warblers, but in this case he saw no foster-parents near them. They seemed to be able to get their own supplies. The green of the kowhai harmonized with their colour.

From Mr. W. W. Smith's (36) account of the hatching of the young bronze cuckoo it is evident that the egg which has been deposited in the nest of the fantail, robin, or warbler takes about ten or twelve days to hatch out, and very soon a tragedy indeed is witnessed. How strange that while we have discussed the altruistic spirit in which many little birds instinctively feed these peevish little orphans—frequently to the detriment or, at any rate, discomfort or partial neglect of their own offspring—yet here we have to face the fact that these very chicks have deliberately done to death scores of individuals which had as much, if not more, right to live than themselves. The young bird, within forty-eight hours of being hatched, blind and almost helpless, fitted by nature with a peculiar hollow between its shoulders (37), spreads its legs, fixes them firmly in the bottom of the nest, wriggles first its head and then its back under one of its companions, balances it, and grips it firmly between its shoulders, and gradually heaves up, one by one, and pushes out through the opening of the nest, its unfortunate foster brothers and sisters.

In about ten days the young bird is fully fledged, and fat, having obtained as much, if not more, food than a brood of four or five warblers would have consumed. It bulges the nest to bursting-point, and probably tears it to pieces in its efforts to get out. I can find no evidence on this point, even about any of the Australian species, and the only descriptions recorded in detail of our birds by the Rev. Mr. Taylor and Mr. W. W. Smith (36) contain the bald statement only, "quitted the nest." I wish some of our Australian ornithologists would refer to the young of the fantail cuckoo, and give us details of their upbringing in the tiny little nest of the *Acanthizæ*.

Do many of these cuckoos perish by these little nests being carried away by the weight of the cuckoo before it can fly? How soon do they leave the nest? And have any instances occurred of the actual discovery of the young cuckoo in one of these nests? The eggs are deposited therein, but are they hatched; and, if so, what is the result? Does the cuckoo throw out its mates? How does it get out of the nest, and when? How long can the nest support its weight?

The movements of the adult cuckoo are quick; it sometimes twists and turns in a tree like a flash. At other times I have seen it sitting very quiet and perfectly still for a considerable time. The male bird usually selects the topmost spray of the tallest trees for its perch during the time it is giving utterance to its remarkable call. He seldom remains long in one spot, and indulges in a restless jerky motion of his tail. "In selecting the nest of so early a breeder as the grey warbler as a home for its young it secures certain advantages for the benefit of its offspring which should not be lost sight of (38). At the period of the cuckoo's arrival the warbler has most probably reared its first brood. Everywhere insect life abounds, so that a proper supply of food sufficient for so comparatively large a bird can be obtained by its little foster-parents with less labour and more certainty than could have been secured two months earlier, when several birds commenced their breeding arrangement."

The trees that the cuckoos are most fond of are the young kowhais, the beautiful light-green feathery leaves forming an effectual concealment for a bird whose plumage is closely approximated in colour. Besides this, the large moth called the kowhai-moth abounds thereon, with many other insects of worth. Another tree cuckoos are fond of is the ngaio, also affected by grey warblers and white-eyes.

The birds consume an enormous amount of flies, gnats, fruit-slugs, moths, and butterflies; the capacity of the young is tremendous, and the number of trips made by a warbler or fantail in feeding one of these birds is incredible. An adult bird has been seen to chase a trout-fly at the end of a fisherman's line.

A young bird was sent to me which had been found dead among a number of sparrows and linnets which had been killed with poisoned grain; but Dr. Benham, who examined its crop for me, found no grain, but a great number of moths, daddy-long-legs, and caterpillars. The bird must, however, have taken some morsel of poisoned food, sufficient to kill it.

The young bird, even fully fledged, has its head, wings, and back a coppery-red colour: this changes in the adult to the well-known bronzy green.

The cuckoos, having continued to lay eggs and to deposit them right up to the end of January, begin in February to prepare for their return migration. By this time they have moulted, and are freshly equipped with plumage. They have been supplementing their insect food, which they find in abundance on our fruit trees, by acquiring a fondness for fruit. Seeing mockers and white-eyes taking fruit, and perhaps themselves pecking at flies or caterpillars on the fruit and obtaining an astonishing supply of some new sweet substance, they are now becoming fruit-eaters like many other of our insect-feeders. Buller (39) scouted my report of a wood-pigeon feeding a young koekoea, as he said a pigeon, being berry-feeding, would know nothing of the insect-feeding necessary for the cuckoo. Yet here we have an instance of the beginning of a complete change of habit, due to change of environment. It is probable that the bird will soon become accustomed to berry-feeding, and, finding sustenance more easily obtainable, fail in many cases to migrate in autumn. That this does happen is well known: a number of instances of cuckoos wintering here (40) are recorded.

A correspondent from Waihi tells us that the birds have been a nuisance in his orchard. Writing on the 9th February he says, "I watched two shining cuckoos—the first pair I have observed here this summer—attacking a Burbank plum-tree to-night; they were literally gorged. I do not know whether this penchant for fruit is extraordinary, but I send you the facts."

At the end of February most of the old birds have gone north so far as New Zealand is concerned, but a gentleman from Taranaki who knows the birds intimately reports from Hobart, Tasmania, "The pipiwharauroa was very plentiful here during the week ending the 16th February, and its joyous note could be heard in every gully. On the 16th, however, we had a very cold snap, with frost, and since then the bird seems to have disappeared entirely. It would be interesting to know if any of your readers have observed anything of the sort in New Zealand."

Several authorities (38) say the cuckoo is a very shy bird, and I have always found it so, but the Maoris say it is easily caught (41). One correspondent says, "The golden-backed cuckoo comes here for a short visit every spring, and always sits and calls in a tall gum-tree between the house and the sheds. After a day or two the birds get bolder, and may be seen within 2 ft. or 3 ft. of my face on any little fruit tree close to the verandah. It also loves a peach-tree which reaches a few feet above the top of the window; and one day, after searching the tree for any grubs, it boldly flitted into the room and perched on the furniture quite fearlessly. I closed the window, and easily caught it. Not knowing what it was, I plucked one marked feather, and reopened the window; it flew off my hand, and continued its search for food, quite unalarmed. It seemed to catch the flies about the room. I have not noticed more than one at a time, but it always comes each year."

The lighthouse-keeper at Kahurangi says they generally leave in March, but he saw two young birds there in April, 1908. Mr. D. Quinn, from Dog Island, says he has seen them at Otakou until the beginning of April.

There is no evidence as to a gradual return along the islands, though this is possible. Buller (42) says they leave in January, but Captain Hutton (43) makes it clear that young ones are often seen in April. He says, "All the old birds leave the south during the first and second weeks in January, but they do not leave the north until the end of January. Some at least of the young birds leave considerably later than their parents, as they have been shot in the South Island in April. Their times of appearance and departure are wonderfully regular in both Islands and the Chatham Islands. Outside New Zealand there is little information."

The bird breeds in Norfolk Island. Mr. Bell tells me that it is seen, though very rarely, at the Kermadecs, and it is probable that its winter home is in New Guinea. I have written to New Caledonia and New Guinea, and hope next year to have something authentic on this point.

Before leaving this interesting subject, I should like to state that all cuckoos were originally nest-builders, and that the habit of parasitism has been slowly acquired. I have gone very fully into this subject elsewhere, and have given the various theories advanced for the adoption of this strange habit (44). Some of the American cuckoos are non-parasitic, but are gradually acquiring parasitism. Cowbirds show all stages of the habit, from ordinary nest-building to true parasitism. Our long-tailed cuckoo inflicts her eggs on many birds, and the chicks are fed by the foster-parents and other kind-hearted birds, notably the warbler, which does not hatch the eggs. Now, when we have a habit such as this, which has been acquired, and which is quite different from the original custom of the birds, we expect occasionally to have what is know as atavism cropping up—that is, a reversion to the original instinct of nest-building. This is exactly what we do find with cuckoos in different parts of the world.

An instance has been recorded (15) of the great spotted cuckoo of Europe having built a nest and hatched its young, though the statement was at the time discredited by ornithologists. The true Indian cuckoos are strictly parasitic, and *Hierococcyx sparveroides* is considered by most observers to be universally so. The Indian cuckoos are seldom seen in pairs, generally singly or in small parties; but this particular species is said by Allan Hume (46) to be more often seen in pairs than any of the others. That this is an evidence of a leaning towards domesticity we find in the interesting fact that Mr. R. H. Morgan, of the Madras Forestry Department, avers that on one occasion he watched this species actually build its own nest, and that he then removed the eggs, of which four were laid.

It is reported of the Kermadec Islands (17) that a reliable observer there has seen old long-tailed cuckoos feeding their young, and he considers that they build their own nest and bring up their young themselves. There is no doubt in my mind that in those cases where a pair of cuckoos are seen together with a number of young ones, the cuckoos have hatched out their brood. There is a strong impression in my mind that the group of fully fledged young birds seen by themselves at North Taieri, able to feed themselves, and having no foster-parents near them, were a brood that had been hatched out together and brought up by their own parents.

In addition to this, cuckoos very often feed young birds. Mr. Ivy (48) gives several instances of African cuckoos lurking about nests, and he saw two adult birds (*Coccystes glandarius*) with five young ones all flying together. This may have been a pair which had mated, built a nest, and hatched out their young; but Mr. Ivy was of the opinion that the old birds had merely collected their brood previous to migrating.

A gentleman from Nelson, well known to myself to be a thoroughly reliable observer, has sent me the following interesting letter, dated the 25th September, 1908: "I have had exceptional opportunities of becoming acquainted with the habits of our native birds, extending over a period of nearly fifty years. Last summer I was prospecting on the Wautui River a week or two before Christmas, and I noticed a pair of these bronze cuckoos close to the camp. I watched them carefully, and they seemed to spend all their time catching flies over a still pool in the river, and continually flying into the bush in one direction. My mate and I spent considerable time day after day trying to find the nest, but could not do so. At last, one morning about daylight, we saw seven of them all round the same pool—five of them were obviously very young, as they could only fly a very short distance at a time. The five young ones would sit on a branch, often the same branch, side by side, and would not change from the position for quite a long time, the old birds continually feeding them, but never the same one twice in succession. This went on for about two or three weeks, every day the youngsters becoming more like the old birds, and taking longer flights. At last, about a month from the time we first saw them, they disappeared, and we never saw them again. Some days after they left I quite accidentally found what I feel certain was their nest. It was in a dry cabbage-tree, under a leaning dead stump about 6 ft. from the ground, and concealed by leaves and rubbish. In and about the nest we found feathers that I am sure once belonged to the old birds. In this instance the whole thing was so clear that it left no doubt in my mind as to their mode of rearing their young." This is a very circumstantial account of the reversion to the habit of nest-building in this pair of birds. The lack of pairing in the ordinary sense of the word leads to parasitism. The action of these two birds in pairing, constructing a nest, or at any rate making a place where eggs could be laid and hatched, feeding systematically, and afterwards teaching five young ones to fly, constitutes one of the most interesting facts in the economy of that generally considered parasitic bird the bronze cuckoo of New Zealand.

BIBLIOGRAPHY AND REFERENCES.

(1.) Buller, " History of the Birds of New Zealand," 1st ed., vol. i, p. 35.
(2.) Tregear, " Comparative Dictionary of the Maori," p. 338.
(3.) Fulton, Trans. N.Z. Inst., vol. xxxvi, p. 133.
(4.) Yate, " An Account of New Zealand," p. 65.
(5.) Polack, " Travel and Adventure in New Zealand in 1839," p. 297.
(6.) Dieffenbach, " Travels in New Zealand," p. 194.
(7.) Taylor, " Te Ika a Maui," p. 618.
(8.) Hutton, " Catalogue of the Birds of New Zealand," p. 21.
(9.) Buller, " History of the Birds of New Zealand," vol. i.
(10.) Hutton and Drummond, " Animals of New Zealand," p. 120.
(11.) Campbell, " Nests and Eggs of Australian Birds," vol. ii, p. 580.
(12.) *Ibid.*, p. 581.
(13.) *Ibid.*, p. 582.
(14.) *Ibis*, January, 1909.
(15.) Kidd, " Instinct of Animals " (*Century Magazine*).
(16.) Kearton, " Our Bird Friends," p. 162.
(17.) Hutton and Drummond, " Animals of New Zealand," p. 124.
(18.) Campbell, " Nests and Eggs of Australian Birds," p. 582.
(19.) Taylor, " Te Ika a Maui," p. 618.
(20.) *Chambers's Journal*, 3rd May, 1902, p. 410.
(21.) Trans. Aust. Assocn. for Advn. Science, Dunedin, 1904, p. 324.
(22.) Fulton, Trans. N.Z. Inst., vol. xxxvi, p. 115.
(23.) *Ibid.*, pp. 125, 126, 128.
(24.) Potts, Trans. N.Z. Inst., vol. ii, p. 66.
(25.) Encycl. Britann., 10th ed., vol. iii, p. 767.
(26.) Buller, " History of the Birds of New Zealand," vol. i.
(27.) Taylor, " Te Ika a Maui," p. 619.
(28.) Dieffenbach, " Travels in New Zealand," p. 220.
(29.) Buller, " History of the Birds of New Zealand."
(30.) Hutton and Drummond, " Animals of New Zealand," p. 312.
(31.) Brehm, " Bird Life," p. 156.
(32.) Newton, " Dictionary of Birds."
(33.) Campbell, " Nests and Eggs of Australian Birds," vol. ii, p. 567.
(34.) Newton, " Dictionary of Birds," vol. i, p. 121.
(35.) Allan Hume, " Birds of India," vol. i, p. 135.
(36.) Buller, " History of the Birds of New Zealand," vol. ii, p. 131.
(37.) Darwin, " Origin of Species," 6th ed., chap. 8, p. 213.
(38.) Potts, Trans. N.Z. Inst., vol. ii, p. 65.

(39.) Buller, "Supplementary Volumes to the Birds of New Zealand."
(40.) Sandager, Trans. N.Z. Inst., vol. xxviii, p. 8.
(41.) Yate, "Account of New Zealand," p. 65.
(42.) Buller, "History of Birds of New Zealand."
(43.) Hutton and Drummond, "Animals of New Zealand," p. 120.
(44.) Fulton, Trans. N.Z. Inst., vol. xxxvi, p. 133.
(45.) Newton, "Dictionary of Birds," pt. i, p. 120.
(46.) Hume, "Birds of India," p. 140.
(47.) Potts, Trans. N.Z. Inst., vol. xxiii, p. 219.
(48.) *Ibis*, 1902.

Art. L.—*The Remarkable Rainfall and Meteorology of Waihi.*

By H. B. Devereux, F.R.Met.Soc.

[*Read before the Auckland Institute, 22nd November, 1909.*]

Before entering into the subject-matter of this paper it will be necessary to refer to the peculiar topographical features of the Waihi district.

Waihi, which is situated on a more or less circular basin, about five miles in diameter, and averaging about 350 ft. above sea-level, lies at the western end of the Bay of Plenty. It is flanked seawards by the high abruptly rising coastal range, and to the west-south-west by the Cape Colville Range, which has its highest point in Te Aroha Mountain. Irregular ridges bound the basin to the south-east, and on the north-west a moderately high range, of irregular features, completes an apparent circle. Several isolated hills of moderate height, mostly described as "barren clay hills," and bearing evidences of the denuding effect of strong westerly winds and heavy rainfall, rise from the plain.

In a meteorological sense, the most notable feature of Waihi is not so much the frequency as the intensity of its rainfall. It will be the endeavour of the writer to throw some light on the agencies which bring about such remarkable records.

First in importance are those cyclones which come (1) from the neighbourhood of Norfolk Island, and, passing eastward of North Cape, pass to the northward of East Cape; (2) approaching East Cape from about north, but passing eastward of it, and when southward of it take a more south-east direction. As a rule, the track of these systems is well to seaward, but sufficiently close to cause very heavy rainfalls. Occasionally the track is across the Island, between Taupo and East Cape: this movement is accompanied by heavy easterly gales, severe backing winds, and intense rainfall. This forward movement across the island, however, is the exception, for the physical features of the land seem to have the power of deflecting these storms to seaward. The passage of a cyclone to the east is, as a rule, not accompanied by heavy southerly backing winds, for Waihi is well sheltered in this respect by the high country to the south and south-east.

Again, a common feature of the meteorology of this locality is the junction of a westerly wave depression with a cyclone, with the usual effect that the wind-force of both systems is neutralised. This fusion is an important factor for heavy rainfall, and will be referred to in greater detail.

The easterly winds of an energetic anticyclonic system often bring heavy falls, for the moisture which they gather from the sea is deposited on the windward slopes of the ranges.

Heavy rain from the west is the exception, for the winds of a depression passing westward appear to have deposited much of their moisture on the high country of the western Waikato and on the windward slopes of the Te Aroha Range.

Another feature well known in the meteorology of the Dominion is the passage of a series of wave-pressures from the west. These waves bring remarkably changeable weather. The winds range from between west-north-west and north-west and west and back again towards the west, these changes sometimes occurring rapidly. Pressure is also oscillatory, sometimes in a marked degree.

Having described the systems which govern the climate, and the topographical features, further and detailed reference will be made to the intense nature of the rainfall.

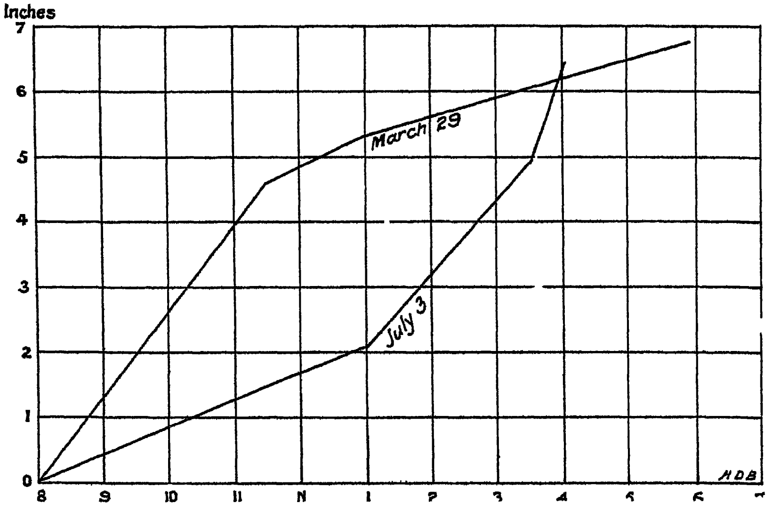
The records have been criticized with some scepticism, and it is well to record the fact that for some years two gauges have been exposed—an ordinary funnel-and-bottle pattern, and a Lander and Smith automatic recording, eight-day-clock movement—one gauge checking the other.

The most prolonged precipitation recorded since 1898, when the observations commenced, was that of January, 1907, when 21½ in. fell in nine days. The records of the Meteorological Office showed the passage of a cyclone of great area from the neighbourhood of Norfolk Island, between the North Island and the Kermadecs. The cyclone had two minima, and great floods were experienced over the Auckland Province—Waihi's total for the month was 25 in., the biggest individual to al for that notable period; Tauranga's total was 20·94 in.; Auckland's approximately 8 in.

The two most remarkable falls recorded locally occurred during the present year, and invite special comment. The first was recorded to 29th March, and the second to 3rd July. The rates of fall are shown in the diagram on p. 410.

In the first instance, the fall of 29th March was due to the passage of a cyclone of unusual extent, which approached East Cape from about north, and, traversing the east coast of both Islands, caused very heavy falls. The barogram of the 29th was remarkable for its waviform trace, and it may be that the air-waves propagated by such a disturbance can be transmitted a very considerable distance. The rainfall was intense within certain limits, as the rates show; the heaviest precipitation appears to have been confined to the coastal hills. A visit to the coast soon afterwards showed the tremendous nature of the fall, which must have been double that which was recorded at the station, three miles and a half distant. In one particular valley the destruction was unique. Residents state that the water came down in a wall 20 ft. high, bringing with it large trees with the soil adhering to the roots; large boulders, one weighing over a ton; and thousands of yards of soil and gravel. Most of the *débris* was carried right down to the sandhills, through which the stream had cut a fresh outlet. It was evident that the damming-up of watercourses and the subsequent release of the obstructions was not the sole cause of the remarkable damage: eye-witnesses state that the rain was flowing down the slopes in cascades. At 1 p.m. there was a single electrical discharge on the coastal range of the nature of a thunderbolt. The shock was severe, and the phenomenon would appear not to have been connected with the "trough" of the cyclone, but to have been due to an atmospheric upheaval on a large scale, the outcome of excessive wave motion. It is probable that some of the remarkably intense rainfall recorded on this date was due to "cloud-bursts." The sky of the previous day indicated considerable wave motion: cirro-stratus (pallium) overlying long lines of waveform cumulo-stratus merging into patches, at intervals of very pronounced "pocky" clouds, said to be an infallible sign of storm in the Orkneys.

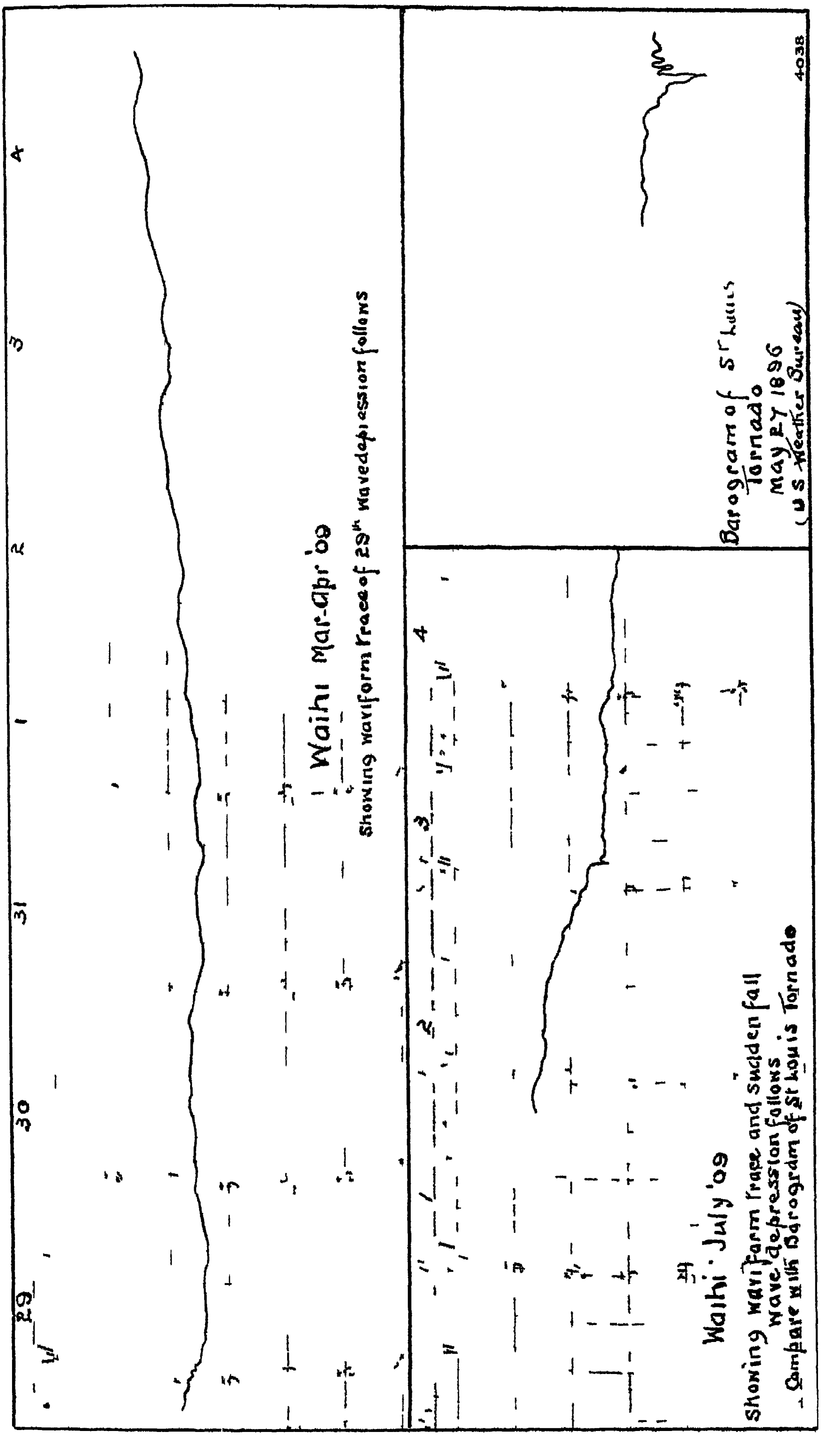
The storm of the 3rd July was still more remarkable, and was associated with the heaviest easterly gale recorded since 1898. The barographic curve



GRAPH SHOWING RATES OF PRECIPITATION AT WAIHI ON 29TH MARCH AND 3RD JULY, 1909.

also displayed wave motion, and depicted the sudden drop in pressure which occurred about 3 p.m.—a decline of fifteen-hundredths in fifteen minutes. This movement was accompanied by wind backing to south-east, and the most intense rain recorded here, 1.15 in. falling in thirty minutes. The barogram suggests the formation of a small "satellite," offset from the parent system, apparently tornadic in nature. The passage of this system was followed by improving conditions, and by nightfall the clouds changed movement from north, again evidencing the fusion of a westerly wave-depression with the low pressure. The glass showed no inclination to recover until the 5th, and anticyclonic pressure was not restored till the 7th. If cyclonic formation is a true circle, then the barometer should regain the height from which it had fallen, and it is evident when this movement is unduly retarded that there must be more than one low-pressure system existent.

Before concluding, reference is made to a remarkable cigar-shaped cloud which forms over Waihi during high west-south-west winds, sometimes five miles in length. This cloud, which has been observed by Davis, Hann, and others elsewhere, and which is described as analogous to the "standing wave" produced by running water on the surface of shallow and rocky streams, appears to be in continual motion, but in reality is stationary,



RAINFALL AND METEOROLOGY OF WAIHI —DEVEREUX

and forms to leeward of the Te Aroha Range. It is often a remarkable spectacle in an otherwise cloudless sky.

Reference is also made to the occurrence of "foehn"-like winds from the north-west in early spring. It is not certain whether these winds blow in front of an advancing disturbance or whether they are due to the influence of high country. The ranges to the north-west are of only moderate height. Certain it is that these winds bring a marked increase in temperature, and have the parching characteristics of the foehn.

CONCLUSION.

It would appear that the cause of the remarkable rainfall of Waihi may be found in—(1) its nearness to the ocean; (2) its situation as regards the track of cyclonic storms; (3) its topographical features; (4) Nos. 2 and 3 operating in combination.

Hann has shown how mountainous districts often produce "islands" of heavier and more frequent rainfall, and that the precipitation does not begin at the foot of the ranges but at some distance therefrom: local observations confirm this.

It may be well to note that Athenree, situated five miles distant to the south-east, almost invariably recorded smaller rainfalls during the passage of a storm. This feature can, no doubt, be accounted for when it is stated that the slope of the land from the sea at this latter station is small, and it presents no bold features.

Frequent reference has been made to the passage of wave-depressions[*] in conjunction with cyclones as a factor for heavy precipitation. Helmholtz[†] has found that atmospheric waves or undulations may exist on a most gigantic scale, in which the wave-length is several kilometres, and so great is the amplitude that when they occur at elevations of one or even more kilometres above the earth's surface their action is felt at the ground. This explanation would appear to account for the waviform barographic trace hereinbefore referred to, and which is generally coincident with intermittent wind-gusts and heavier bursts of rain. Since the upheaval of air in the truly mountainous waves must amount to hundreds of metres, causing a mixture of air-layers, it is easy to conceive that precipitation would occur; and this impulse would accelerate and extend higher upwards the movement already begun.

It may be that the passage of a wave-depression concurrently with a cyclonic area would set up wave-interferences attended with "breaking" phenomena. Helmholtz explains that the counterparts in the air of breaking spraying water-waves would cause a mixture of air-layers. Hann[‡] has shown how saturated layers of air, being forced to rise, expand, and by expansion become cooled below the dew-point. If this process, already begun, is accelerated, further cooling would result, and it is easy to conceive of the enormous quantities of rain which may fall under these conditions.

EXPLANATION OF PLATE XXXIX.

The upper part of the plate is the barogram for the week ending 5th April, 1909. In the lower part of the plate the Waihi record of 3rd July, 1909, shows similar waviform trace and sudden fall to that of the St. Louis tornado of 27th May, 1896.

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[*] Captain Edwin, Trans. N.Z. Inst., vol. xxxvii, p. 557.
[†] Waldo, "Modern Meteorology," p. 335.
[‡] Hann, "Handbook of Climatology."

ART. LI.—*Captain Dumont D'Urville's Visit to Whangarei, Waitemata, and the Thames in* 1827.

Translated from the French* by S. PERCY SMITH, F.R.G.S.

[*Read before the Auckland Institute, 22nd November*, 1909.]

WE left the "Astrolabe" off Tokomaru Bay, north of Gisborne, after having visited Tologa Bay (see Transactions, vol. xli, p. 130), and will now take up her further voyage to the north, and describe the visit of the French expedition to the Waitemata, the present site of Auckland, in 1827.

After leaving Tokomaru there are no incidents of particular interest until the corvette reached the Great Barrier Island, though she sighted White Island and many of the other groups of islands in the Bay of Plenty, and nearly suffered shipwreck on the Mercury Islands during a violent storm.

As in the previous cases, the translator's notes appear within square brackets [ ].

D'Urville's intercourse with the Ngatai-Paoa Tribe of Maoris at the Tamaki is of peculiar interest; and, moreover, his meeting with Rangituke's expedition at Whangarei has served to fix the exact date of an important event in the history of the Auckland isthmus, the full history of which is to be found in "The Peopling of the North" and the "Wars of the Northern against the Southern Tribes in the Nineteenth Century," published by the Polynesian Society.

With regard to D'Urville's claim to have been the discoverer of the Manukau Harbour, we must, in fairness, deprive the celebrated Frenchman of that honour, for it was Marsden (with whom was the Rev. Mr. Butler) who first visited those waters, as the following extract from his MS. journal, now in the possession of Dr. Hocken, who has very kindly sent me a copy, will prove: "November 3rd, 1820. . . . when I went to the top of a very high conical hill [Mount Wellington, or Maunga-rei], near the settlement [Mauinaina, across the water from Panmure]. From its summit may be seen both the western and the eastern shores of New Zealand. One river [the Manukau] which ran into the western ocean seemed to join the Wyetematta [Waitemata] and the Magoea [Mokoia; really Tamaki, Mokoia being the basin south of Panmure] Rivers, as I could not see any land that separated them [Otahuhu isthmus would be invisible from Mount Wellington]. On inquiry, I learnt that one river [Wai-uku] which I saw ran towards Wyekotta [Waikato], and the other was called Manukou [Manukau], which fell into the sea on the west side." . . . On the 9th November, "wishing to ascertain whether the River Manukou did unite with the Magoea River or the Wyetematta, I determined to proceed immediately to Manukou to satisfy myself on that head. . . . We reached Manukou in the evening. . . . We found an extensive harbour, and saw the Heads at the distance of about 5 leagues. . . . I informed him that the object of my visit was to examine the Harbour of Manukou, and that we intended to go down to the Heads to see if there was an entrance for ships." . . . 10th November: "Though the communication between the western and eastern seas is not entirely complete, yet it is very nearly so. . . . In the Manukou there are very extensive shoals and sand-banks, but there appeared to be a channel of deep water, but which we were unable to examine in the canoe from the strength of the tide, which occasioned too great a sea to venture into it with safety. The entrance into the harbour is also narrow, and it is probable a bar may be found on the outside, but this we could not ascertain, as it would not be safe to go out to sea in a small canoe when the swell is so great; within the Heads we had 10 fathoms of water."

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* Voyage de la corvette L'Astrolabe, exécuté par ordre du Roi, pendant les années 1826, 1827, 1828, sous le commandement de M. J. Dumont D'Urville (Paris, 1833), vol. ii, p. 111 *et seq.*

The above clearly proves Marsden to have been the first discoverer of Manukau. Apparently he went down the harbour to beyond Pupoñga Point, as the soundings and other things prove. Marsden was there six years and a half before the "Astrolabe" entered the Waitemata, a fact which D'Urville could not have been aware of, for the above quotations are not printed in the "Missionary Register," and it was from that source that D'Urville obtained the other information as to Marsden's doings which he so freely quotes in his third volume. Judging from D'Urville's observations scattered throughout his works, he would be the last man to deprive a prior discoverer of the credit which is his due.

With respect to the name "Astrolabe Channel," which D'Urville gave to what is now known as the Waiheke Channel, his name must also give place to another which had previously been given to it by Major Cruise, of the 84th Regiment, who, in the colonial schooner "Prince Regent," belonging to the New South Wales Government, under the command of Captain Kent, entered the Rangitoto Channel on the 21st August, 1820, and thence passed along the Waiheke Channel to Coromandel, where H.M. storeship of that name was then taking in spars for the Admiralty. On her return north the schooner again passed through the channel, and left by way of the Motu-ihi Channel on the 3rd September, 1820. Cruise, in his "Journal of a Ten Months' Residence in New Zealand," p. 209, says, "The passage above mentioned was called 'Prince Regent's Channel,' because that vessel was the first by which it was known to have been navigated." Marsden also passed up the Waiheke Channel on his way to Kaipara from Coromandel two days before the "Prince Regent" first entered it, but he does not appear to have given it a name, and therefore Cruise's name, "Prince Regent's Channel," should stand.

[VISIT TO WHANGAREI.]

CHAPTER XIV [part of page 142].

20th February, 1827.—At daybreak the land which had been in view all night showed up at less than two leagues' distance to windward, and the whole of the island of Otea [Aotea, Great Barrier] was developed to its full extent. It is formed by a chain of elevated mountains, cut up by deep ravines, and is generally sterile. A small island situated on the N.E. of Otea [Rakitu], which we passed at about two miles and a half distant, offers a most arid aspect. On the whole coast of Otea we did not remark any indication of inhabitants; no smoke denoted the presence of human beings. By noon we were at a point precisely to the east and less than half a league from the north point of Otea. On that side the island is terminated by a peninsula, without vegetation, of a brownish colour, and the flanks of which.

battered by the sea, have something of a lugubrious though imposing appearance. It is also accompanied by some pointed rocks of singular shape, some of which are very slender on top. For this reason we gave to that part of Otea the name of Pointe des Aiguilles [still so called]. At the same time the soundings were 72 fathoms, hard yellow mud.

As soon as we had passed the Pointe des Aiguilles, we discovered successively the numerous islands dispersed at the entrance to the Bay of Shouraki [Hauraki], a view which produced a most picturesque and animated scene. Here the work of Cook was again found to be very unexact, and a new exploration became indispensable.

With the wind W.N.W. then prevailing I already flattered myself with the hope of doubling the north point of Otea, and of penetrating into the Bay of Shouraki by the channel which lies between that island and Shoutourou [Hauturu, Little Barrier]. A black squall, however, rose in the S.W., and prevented me, and therefore I kept away to starboard. At 1.30 the squall burst upon us with violence, but it did not last long. Presently the sky cleared, and the wind returned to the S.S.W. and obliged me to keep outside the islands, and soon after we sighted the Poule et les Poussins [Hen and Chickens Isles], just before night. At 12 p.m. a brilliant meteor showed in the east for some seconds.

21st February.—When daylight came we sighted all the land seen the previous evening, and at the same time found that the current had driven us eight or ten miles to the north. We also commenced to see the Tawiti Rahi (Poor Knights of Cook) [Tawhiti-rahi] and the broken summits of Tewara [Bream Head], although distant one and the other nearly twenty-five miles.

At noon we passed, at six miles distant, to the north of the islets, apparently uninhabited, of Moko-Hinou [Moko-hinau]. The breeze having changed to the S.E. and even E.S.E., I steered the corvette under all sail towards the Harbour of Wangari [Whangarei], where I hoped to cast anchor before night. Unfortunately, at the moment when we arrived on the meridian of the east group of Moro-Tiri (and it was already 4.30), the breeze fell, and barely allowed us to move more than a knot an hour. It was then impossible to stand out to sea, and I decided, as well as I could, to gain the anchorage of Wangari, with the sounding-line in hand. We passed at less than half a league the narrow and lofty chain (*sic*) of Moro-Tiri. [The Moro-tiri, or Chicken Islands, however, are, comparatively speaking, quite low; probably D'Urville means the Hen Island.] On its desert shores nothing but the monotonous sound of the breakers and the fearful cry of the sea-birds was heard.

Up to midnight we had successively from 48 to 22 fathoms of water, sand, and shells. . . . At 4.30 in the morning of the 22nd I laid to; and at 6 a.m., having recognised the land at less than three miles off, I stood towards Cape Rodney. Soon the sky, up to that time clear, became overcast from the east, with a heavy sea, and it appeared as if bad weather was again setting in. I did not judge it prudent to expose ourselves to the fury of the wind on an open coast, and thought it better to find an anchorage in shelter.

In consequence, I steered towards the head of Wangari Bay, where I hoped to place the "Astrolabe" under the shelter of Cape Tewara. Unfortunately, we had already fallen too far to leeward, and a bank appeared in our route, which obliged us to anchor in the mouth of the bay in a place little sheltered against the wind prevailing.

Hardly had we anchored when the sky became entirely overcast, and the wind blew with force from the S.E., accompanied by much rain and a heavy sea. Nevertheless, it was not long before we distinguished a long war-canoe coming from the head of the bay, and approaching us, urged by all the vigour of those on board, for they managed their craft with extreme ability. It was not without interest to see that long and frail vessel mounting and disappearing alternately over the rough waves. These Natives were in the national costume of New Zealand—that is, mats of mouka (*Phormium tenax*) [muka], more or less thick, with the exception of one individual, who was properly dressed in English garments. I at first took him for some deserter established amongst the Natives, the more so as he accosted the corvette without hesitation, mounted on board, and asked for the *rangatira rahi* [principal chief], and advanced towards me with a deliberate air. It was not until I heard him speak, and examined his partly tattooed face nearer, that I discovered he was in reality a Native.

Soon, by aid of a language half English, half New-Zealand, often aided by significant gestures, I came to understand that my guest was named Rangui [Rangituke], son of Te Koki, principal chief of Paihia, Bay of Islands, whom I had visited four years previously. He said, with pride, he was a companion of Pomare [killed by Waikato, on the Waipa River, in 1826], and, although he concealed part of the truth, I suspected very quickly that he was at this time engaged in some military expedition against the people of Shouraki Bay.

One of his lieutenants, named Natai [? Nga-tai], decorated with regular tattooage, attracted our attention. The facile pencil of M. de Sainson has reproduced with fidelity the features and the *moko* [tattooing] of this New Zealand warrior (see pl. xliii). [Plate XL.]

Rangui gave me to understand that he had resided some time at Port Jackson, where he had acquired his semi-European manners. In order to convince me, he showed me with much gravity a torn sheet of paper, which I at first took for some certificate of a whaling captain. In effect it was a certificate, but under the name of two individuals of Sydney, attesting the fact that they had lodged Rangui for some days, adding that the latter had promised in return to send them some spears, shells, and other objects of the country. These two people, in consequence, invited all captains into whose hands the paper should fall to remind the bearer of that promise. That pleasant invitation amused me much, and I thought that those invited would think much more of securing such things for themselves, rather than for the two comrades of Port Jackson. For the rest, I returned to Rangui his paper, with a serious air, as if its contents had given me much information about him, and he appeared very well satisfied.

After having examined for a moment the weather, our ship, and our anchorage with as much aplomb as an experienced pilot, he declared that we were in a very bad place, that the weather was going to be worse, and that our ship would certainly perish if we did not change her position. At the same time he indicated the head of the bay, and assured me we should be in perfect safety there, and used all his eloquence to persuade me to remove thither. Without doubt he was right, which I knew well; and more than he I desired the power to conduct the corvette under the shelter of Tewara Peninsula, but the weather which prevailed did not permit me to attempt it. Te Rangui, who could not understand my reasons, exerted himself to demonstrate the necessity of leaving that anchorage, and added the menace of an approaching shipwreck. Seeing that he could not prevail, he sent his canoe ashore and remained with me himself.

At my request he gave me, with intelligence and complaisance, the names, in the language of the country, of the adjacent lands and islands, which I have, as usual, substituted for those of Cook.

On these coasts, occupied by a people endowed with so much sagacity, and who have not left an islet, a rock, or a corner of the land without a name, it seems odd to a navigator to see none but English names, often applied without taste. It is much more interesting to use the Native names, which are certain to be understood by them, and to be able to indicate thereby the places to which he desires to direct his ship. Without doubt it is a sacred duty on the part of the navigator to respect the names given by the first discoverer of uninhabited places; but, everywhere else, I think that those of the indigenous people should prevail so soon as they are known. A time will come when these names will be the only vestiges of the language spoken by the primitive inhabitants.

Immediately after anchoring, I sent M. Pâris to sound all round the ship, from the N.W. to the S.W., and determine the limit of the 5-fathom line. The result of his operations was that the deep water nearly touched the coast. As we were more than two miles distant, it assured me that in case of accident we should have plenty of room to drift.

The weather threatened more and more. At 12, I attempted to get under way to advance farther up the bay; but our capstan, always in bad order, slipped at each violent shock of the waves. I feared that the intended movement, in place of being advantageous to us, might become fatal, so I decided to remain as we were, the more so as the anchor held well, although we had at that time only 40 fathoms of chain out.

The weather being somewhat better at 3 p.m., I sent M. Lottin towards the head of the bay to make a survey of it. He returned at 5.30 p.m., after having found an excellent anchorage at the entrance of a fine channel, which is probably the mouth of the Wangari River.

Te Rangui had passed the day on board very happily, and decided to spend the night with us. But nothing would prevail on him to accompany us to the head of Shouraki Bay. The very idea of communicating with the inhabitants of that country seemed to cause him much terror. Neither prayers nor promises could conquer his repugnance, nor even the offer of a musket, a bait so powerful to a New-Zealander.* He told me that Temarangai [Te Marangai], chief of this district, lived on the Wangari; and he added that he would go and inform him of our arrival, and invite him to bring some hogs, if we would only wait three or four days.

All night the sea was very heavy, the breeze fresh and uncertain, and the heavens overcast. The "Astrolabe" rolled heavily, but without too much strain on her.

23rd February.—At 5 a.m., seeing that the wind and the sea would not permit me to make sail, I wished to profit by the delay to visit the bay at the entry of the river, and the encampment of Te Rangui. Followed by MM. Quoy, Lottin, Lauvergne, and Te Rangui, I directed the whaleboat towards the point of sand situated N.N.W. of our anchorage.

[* Te Rangi and his tribe, Nga-Puhi, had been at war with the Thames tribes for many years past; and, indeed, his tribe, under Hongi, had inflicted such numerous defeats on them that it would not have been safe for Te Rangi to have shown himself there.—TRANSLATOR.]

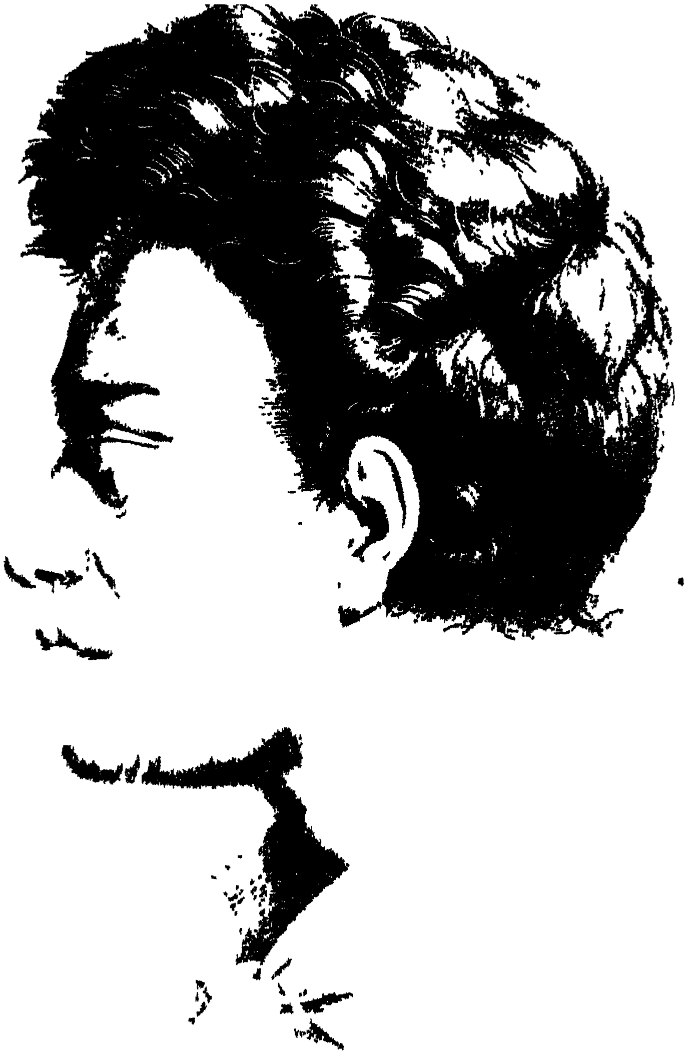

PLATE XLIII OF D'URVILLE'S "VOYAGE": PORTRAIT OF NATAI.—SMITH

On our way thither we met the three canoes of Rangui, which were coming off.* The largest was ornamented both fore and aft with plumes and tufts of hair, and the whole length of its top-sides sculptured in bas-relief, painted in red, often enriched with shell, the whole executed in the best New Zealand taste. Rangui addressed some words to his warriors, and then insisted on accompanying me in my excursion, though I offered to leave him in his canoe. A considerable bank of sand which extends nearly a mile out from the coast reduces the entry to Wangari so much as not to leave more than half a mile of clear space. The interior offers an excellent anchorage, where one would be sheltered in all parts; and the south wind, which alone could enter, would not cause much sea, on account of the configuration of the adjacent lands. Along the high land towards the north 10 and 12 fathoms are found close to the shore.

The entrance of the river itself has half a mile of width, and expands into a vast basin of from two to three miles in width, where ships like ours could doubtless enter. We debarked near the north point, and M. Lottin and I climbed up to the summit of a ridge which dominated both the exterior and interior basins. From that point the eye wandered at will over the sombre summits of Tewara, surmounted by sharp peaks often disposed like the fingers of the hand, and over the low and sandy flats which bordered the opposite side of the channel at my feet [Township of Marsden; landing-place for Waipu], and, above all, over the vast and peaceful basin of the waters of Wangari, surrounded on all sides by shores covered with a robust vegetation. Pleasant isles elevated themselves on its surface, whilst the course of the river disappeared in the mountains situated towards the sunset.

Probably, like all those which have been found up to date in these islands, this river, in spite of its imposing aspect at its mouth, is but a large creek of salt water, ending soon in a torrent more or less voluminous, which in summer and at low water often offers but a small stream of water. That disposition of the New Zealand rivers, so much in conformity in appearance with those of New Holland, arises, I think, from a different cause. In New Zealand I attribute it naturally to the extreme irregularity of the soil, to the height of the mountains, and, above all, to the little width of the islands of which that land is composed, which does not permit the water-courses to attain any considerable volume before pouring out into the sea. It is needless to prove that the same reason is not admissible for the Australian Continent.

Whilst admiring the beauty of the scene spread out before us, and the vigour of the vegetation, I was astonished at the silence which reigned on all sides, and the absence of all human creatures on a soil so fertile. But I recalled to mind the warlike habits of the New-Zealanders, and, above all, the wars of extermination which the people of the north declared each year against the unhappy tribes of Shouraki Bay. In fact, in rambling in the neighbourhood, I soon discovered in the scrub which covered the soil the scattered remains of numerous houses. A village had formerly occupied that eminence, and its inhabitants had been destroyed, or had fled to the interior to escape the fury of the Bay of Islands tribes, guided successively by Korokoro, Pomare, Shongui [Hongi], &c.

[The Whangarei Natives—Parawhau and other tribes—were generally allies of Nga-Puhi of the bay, but not always, and frequent wars between them have taken place. But the desolation of the country referred to by D'Urville was caused by Ngati-Whatua, of Waitemata, who, in 1824, had destroyed or driven away most of the inhabitants around Whangarei Heads. See "Wars of the Northern against the Southern Tribes in the Nineteenth Century," p. 148.]

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* Pl. xl

Here, in spite of most favourable circumstances for the researches of an entomologist—a brilliant sunshine after a long rain—I had occasion to remark again the singular paucity of many species of insects on the soil of New Zealand—no *Coleoptera*, no *Lepidoptera ;* nothing but some *Orthoptera*, *Hemiptera*, and *Diptera*, such as locusts, crickets, bugs, and flies. The birds were more numerous, but very wild. Excellent oysters covered the rocks, and large sea-weeds carpeted the intervals between them.

As soon as M. Lottin had completed his work, which took about an hour, I made my way towards Rangui's camp, which was established on a little flat under the flanks of Tewara Peninsula, and sheltered from all winds. A rapid glance over his establishment soon convinced me that it was but temporary : it was only a flying camp, where that *rangatira* had placed himself with his troop as a vedette awaiting the rest of the army. Two or three huts made of branches served as tents ; a great number of baskets full of fern-root (ngadoua) [aruhe] ; a quantity of fish suspended in the air to dry, of which half were decomposed, exhaling a disagreeable odour ; bundles of spears, and sometimes muskets covered with mats : behold the baggage of these adventurers ! There were no pigs, no appearance of cultivations—nothing but a handsome cock, which I purchased.

As nearly all had gone on board the ship, there only remained on guard one man, two or three women, and some children.

Having questioned Rangui more particularly, after some shifting he ended by avowing that he was conducting the advance guard of a military expedition directed this year by the people of the Bay of Islands against those of Waikato, whose ruin they had sworn. He awaited from day to day the arrival of the other chiefs to advance towards the south. He was delighted at hearing that I intended to anchor at Paroa [Bay of Islands] ; his eyes filled with tears when I said I should see his father, Te Koki,* and expressed his pleasure by all sorts of testimonies of friendship.

As I judged the weather would permit me to get under way, I dissuaded Rangui from returning with us, and took leave of him. Half-way back I met the three canoes returning ashore. Already I was felicitating myself on being disencumbered of our importunate guests during the time we were getting under way, when on my arrival I was altogether nonplussed to find that six of them remained on board. Instantly I embarked them in the whaleboat, and landed them on the nearest point. Nevertheless, this caused a delay of two long hours, and it was noon exactly when we got under way.†

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* [A great deal is to be learnt about this turbulent old chief in "The Life of Archdeacon Henry Williams."]

† [The expedition of which D'Urville saw the advance guard at Whangarei Heads, under the chiefs Te Rangi-tuke and Hori Kingi, about April or May, 1827, was defeated near Tamaki Heads, Waitemata, by Ngati-Tipa, Ngati-Paoa, and some divisions of Waikato, and nearly the whole of the Nga-Puhi were killed. They were led into an ambush. and very few escaped back to the Bay of Islands to take the news. (See "Wars of the Northern against the Southern Tribes in the Nineteenth Century," p. 191.)—TRANSLATOR.]

[VISIT TO WAITEMATA.]

CHAPTER XV.—EXPLORATION OF SHOURAKI BAY; DISCOVERY OF THE ASTROLABE CHANNEL.

We steered to the S.E. with a fine breeze from the north, keeping two and three miles off the coast. From the anchorage up to Cape Papai-Outu [Paepae-o-tua; Bream Tail], which forms the southern point of Wangari Bay, the coast is low and bare [this low coast fronts the Waipu Settlement], and does not rise until after the cape is passed, where it becomes also partly wooded. Beyond that again there is nothing but a series of uniform dunes, almost bare. up to four or five miles from Cape Tokatou-Wenoua [Toka-tu-Whenua*] (Cape Rodney of Cook). After that the land rises again, and is less mournful in appearance. On our left we passed the elevated summits of Moro-tiri [Taranga] and the rock Toutourou [Tuturu], like an isolated sight on a cannon, without any appearance of verdure.

At 7 p.m. exactly we passed between the Cape Tokatou-Wenoua and the high island Shoutourou [Hauturu, Little Barrier], at less than half a league from the first, and about six miles from the latter. The point of Tokatou-Wenoua is not itself very elevated, and not until four or five miles in the interior is it surmounted by a peak of about 150 toises [1,500 ft.] in height [Mount Hamilton, Tamahunga].

The soundings, which all the afternoon had indicated 32 and 33 fathoms, increased to 40 near the cape, although the distance from the coast was only half as much as before. After passing it the indications again became uniform, of 31 to 33 fathoms, as before, right up to mid-channel between the main and Shoutourou. The night was very fine, and we passed it peacefully, lying to.

24th February.—From 4 a.m. I steered to the W.S.W., to approach Cape Tokatou-Wenoua. When daylight permitted us to see the land I saw that the current had carried us during the night six or seven miles towards the Cape Moe-Hao [Moehau] (Cape Colville of Cook). I endeavoured to follow the coast as closely as possible, for my intention was to enter amongst the islands to the west that Cook had only noticed hastily and in a very vague manner, so much was I desirous to complete the work of that great navigator.

Although the wind had become very light, at 8 a.m. we passed opposite a projecting point terminated by some islets, and behind which should be found an excellent anchorage [Tawharanui Point, just south of Whanga-te-au Bay]. An instant after, a reef awash showed right ahead, which we passed at 400 toises, whilst M. Guilbert went to reconnoitre it. It is a small plateau of little extent, and which offers no danger, having all round it 17 fathoms of water.

With a fair wind we passed before a deep bay, which contains many islets, bays, and channels. Towards 2 p.m. we passed under full sail between an island to port (Tiri-Tiri-Matangui) [Tiritiri-matangi] and a peninsula on the right which is only joined to the mainland by a narrow isthmus [Whanga-paraoa Peninsula]. In the channel, which is two or three miles wide, the soundings decreased regularly from 20 to 17 fathoms.

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* [Near Cape Rodney is a place named Te Waka-tuwhenua, or the "Canoe of the lepers." Here one of the ancient canoes that came from the Eastern Pacific landed her crew, who had the leprosy, and nearly all died soon after landing.—TRANSLATOR.]

After this we entered a spacious gulf on the west side of Shouraki Bay, where we were obliged to make some bords to approach the land in a S.W. direction.

This fine basin has ten or twelve miles of extent either way. To the S.E. it is bounded by a chain of islands of moderate height [Rakino, Motutapu, Rangitoto, &c.], and well wooded; to the west by a uniform perpendicular coast, sad-looking and sterile; to the N.N.W. a large channel appears to enter into the land [Te Weiti River]. But I preferred to direct my researches towards another opening in the south, which would, according to my calculations, allow me to approach the opposite coast of New Zealand, and which appeared to reduce to very little the width of Te Ika-Na-Mawi [Te Ika-a-Maui] at this point. I even thought that there might exist here a channel which separated the land into two islands.

We had not remarked any trace of inhabitants, only two or three smokes a long way in the interior. One cannot doubt that this extreme depopulation arises from the ravages of war.

The breeze having very much decreased, and changed to the W.S.W. in the evening, we let go the anchor in 12 fathoms, soft mud, at four miles off the coast. In a few instants the crew had brought up on their lines an immense quantity of fish, which was exquisite eating. During the afternoon a small hammer-headed shark had followed the corvette.

25th February.—The hammocks were stowed at 5 a.m., and a few minutes afterwards the "Astrolabe" was under sail. The wind having become steady in the S.S.W. obliged us still to beat against it, and I saw that it would take us a good part of the day to attain the pass to the south. In order to profit by this, I jumped into the whaleboat with MM. Lottin, Gaimard, and Lesson, to go and explore the interior channels. At a distance of about half a league we had the pleasure of seeing the "Astrolabe" sailing the tranquil waters of a basin surrounded by land on all sides, her hull lightly balanced on the surface of the waves, her sails softly filled by a light breeze, a lively contrast to the absolute silence of nature. Lost in the immensity of the ocean, like a point, the mass of a ship takes on all its importance as soon as it approaches any object with which it can be compared. The effect which this spectacle produces is perhaps more striking still to the navigator who, enclosed within that floating home, finds in its ordinarily restricted dimensions the reason of the constraint he feels.

At the end of two hours we entered the pass which had excited our curiosity. On the left is an island (Rangui-Toto) [Rangitoto], low at its extremities, surmounted by a peak in the centre, and of which the flourishing vegetation contrasts in a singular manner with the nakedness of the opposite coast. We soon found ourselves in a beautiful interior basin, in which we got 6 to 8 fathoms regularly, and which soon divided into two channels: the one turned to the east, of which we could not discern the extremity [Waiheke Channel]; the other, which ran to the west, seemed to us to be land-locked at two or three leagues distant.

We entered the latter, and debarked on the right-hand shore. Whilst M. Lottin made a geographical station on the summit of a peak which since last evening we had observed from a long distance [probably Mount Victoria, or Takapuna], I cast an eye on the surrounding country. Covered in abundance with herbaceous plants, there are some bushes, but no trees. Already the heat seemed to have destroyed a great part of the vegetation; and the soil, although fertile, seemed to me to be without fresh water, for I could only find a pool, which was brackish. Birds were very scarce; we were only able to shoot a few species on the shore; we did, however, notice a quail analogous to that of Europe. All along that beach we felt a heat to which we had not been accustomed since our arrival on the New Zealand coast.

At half an hour after noon we re-embarked to cross the arm of the sea, and landed on the southern shore. At the side of the water we found an abandoned village, composed of over a hundred houses; but we saw they were merely huts built of branches, constructed solely to serve as a temporary shelter for the Natives on their great fishing excursions, or on some military expedition.*

Always occupied with the idea that the ocean would be found at a short distance to the south, I resolved to cross the narrow isthmus which separated it from us, or at least reach a mount distant about two leagues [? Mount Eden], from the summit of which I hoped to discover the two seas. I took Simonet with me, and MM. Lottin and Gaimard, to whom I communicated my project, and who wished to accompany me. Their society was as useful as agreeable, for in traversing these unknown solitudes one runs the risk of meeting at any moment with savages whose intentions might be suspected. For the rest, I placed confidence in the fact that I carried nothing that might excite their cupidity. Simonet alone had an indifferent gun.

We were at first favoured by a little well-trodden path, which led precisely in the direction I wanted to go. For a long time I thought it would lead us to some habitation. For about an hour we passed across hillocks covered with high fern, scrub, and sometimes coppices, cut up by gullies in which ran streams of fresh water. To our great regret our path vanished by degrees, and ended at a small but thick wood. However, as we were not more than two miles from the eminence which I wished to attain, we therefore tried to continue our route; but after half an hour of unheard-of efforts and extraordinary fatigue, which barely permitted us to advance two hundred paces, we found ourselves in a place so swampy and interlaced with ferns, dry shrubs, and brushwood that it became impossible to place one foot before the other. In an attempt to proceed farther M. Gaimard had a fall, and was near being dangerously hurt.† It became necessary to return, a task rendered more difficult on account of our exhaustion. The ligneous *Veronica*, *Leptosperma*, Epacrids, and some Cyperaces, and, above all, the edible fern, formed the principal vegetation of these deserts. No trace of cultivation offered to our view. Beyond the path which we followed we saw no other vestiges of the presence of man except some fallen trees and a few places where the earth had been freshly turned over to procure roots of the fern (ngadoua) [aruhe], one of the principal bases of nutriment of the inhabitants of these regions.

[Apparently D'Urville passed from the harbour through what is now Parnell, and the place he finally turned back from was the wood and swampy ground that formerly existed on the site of the present Newmarket.]

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* [It seems probable that the point where D'Urville landed was either in Judge's or St. George's Bay. None of the Ngati-Whatua were living about the Waitemata at that period, having abandoned the country and gone to lower Waikato and Manukau, in consequence of their great defeat at the Battle of Te Ika-a-ranga-nui, in February, 1826, at the hands of Hongi.—TRANSLATOR.]

† See note 14 [extract from M. Gaimard's journal, of no particular interest. TRANSLATOR].

From the neighbouring heights we remarked that the channel where our boat was left debouched to the west into a large basin which extended indefinitely to the north [the upper Waitemata]. It is very probable that the latter communicates with the channel we had observed the previous evening in the N.N.W. of our anchorage [? the Weiti River]. Everything indicates that in these parts the island Ika na Mawi [Te Ika-a-Maui] is cut up by many channels and creeks, which form bays and harbours, some better than the others.

Towards half past 3 we quitted those parts, and an hour afterwards we were on board. Profiting by the favouring tide, M. Jacquimot had brought the corvette to the entry of the pass between Rangui-Toto and the land of Toka-Pouni [Takapuna, Mount Victoria; the north head is Takarunga]. As soon as the whaleboat was hoisted in I hauled the tacks to starboard, having decided to enter the eastern channel. Aided by a fine breeze from the S.W., I quickly doubled to windward the island Rangui-Toto, and at twenty-five minutes past 5, at the moment when we passed its southern point, at less than 300 toises, the sounding-line, which was dropped alternately and continuously on either side, showed diminished soundings from 6 to 5, 5½, and even 4 fathoms. I luffed up, in spite of breakers which encircled us on the south, when the soundings gave us 6, and afterwards augmented up to 8 fathoms. At 6.30 p.m. I saw myself surrounded by land in all directions, and the channel was much contracted. Fearing to fall into a place less favourable to anchor, and not wishing to go any farther, I let go the starboard anchor in 8 fathoms, muddy bottom. Twenty fathoms of chain sufficed to place us in a position without anxiety. The night was very fair, and I was able to enjoy a perfect repose.*

26th February.—At 5 a.m., impatient to pursue our discoveries, and with a slight breeze from the S.W., accompanying charming weather, I made sail in order to advance farther up the channel into which we had penetrated. But the wind, after veering to the S. and S.E., suddenly fell altogether, at 7.30 a.m., and left us in a dead calm. At the same time three canoes, which we had long since seen coming from the south shore, arrived alongside. I soon learned that they belonged to Rangui [Rangi-hua], chief of these parts; he himself, dressed in a Scotch tunic [? kilt], was in the largest of the canoes. On my invitation he mounted on board at once, and without distrust, and advanced towards me with a grave and assured pace, and offered me the salutation of etiquette (*shongui*) [*hongi*]. I ordered that all his warriors should remain in their canoe, and only permitted him and his brother and companion-in-arms, Tawiti [Tawhiti, or Waero], to come on board, which did not seem to cause him any repugnance.

Te Rangui, whose height was 5 ft. 9 in., was a very fine man in every sense of the word; his gait was noble and imposing; and his features, though ornamented with numerous furrows—marks of his rank—expressed an air of calm confidence and dignity in a remarkable degree. It was not long before we became the best friends in the world, and, during the course of the long conversation we had, the following are the principal things I was able to catch: The Natives of Shouraki [Hauraki] are in continual war with the people of the north, who come each year to ravage their territories. The firearms give an immense advantage to the latter, and Rangui testified the most lively desire to obtain some for his tribe. A year has barely passed since he fought with guns against the redoubtable Pomare. After having exchanged several shots, Pomare had finally succumbed. As is the custom, his body was devoured on the field of battle, and his head, prepared in mokomokai, was conserved in the Waikato Pa, the principal fortress of the league of the people of Shouraki Bay. I could have become its owner for a few pounds of powder; it was only necessary to wait four or five days, the time required to send a messenger to bring the head from Waikato. That proposition was assuredly very seducing to me, and I should have been pleased to have taken to Europe the skin [or head] of a warrior so famous in these antarctic regions. Unfortunately, the exploration of New Zealand was only a secondary object of the expedition, and my instructions were to proceed to the tropics.

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* See note 15 [being an extract from M. Quoy's journal, which is of no interest except that he mentions the volcanic nature of the surrounding country.—TRANSLATOR].

[Pomare, the celebrated Nga-Puhi warrior and leader, had been killed near Te Rore, on the Waipa branch of the Waikato, in about the month of March, 1826, together with almost the whole of his war-party, only some half a dozen men escaping to carry back the news to their homes. The expedition of Te Rangi-tuke that D'Urville saw at Wangarei was organized to obtain revenge for Pomare's death. Te Rangi and Tawhiti's tribe, Ngati-Paoa, assisted at the death of Pomare.]

Rangui and Tawiti, impressed with the desire to satisfy my curiosity, gave me also the names of the districts, channels, and islands surrounding us. It is thus that the following names figure on our chart—namely, Rangui-Toto [Rangitoto] for the volcanic island situated N.W. of the anchorage; Taka-Pouni [Takapuna] for the shore opposite; Wai-Tamata [Waitemata] for the channel to the west; Wai-Mogoia [Mokoia, an old pa near Panmure; Tamaki is the name of the channel], a channel to the south; and Wai-Roa [Wairoa River] for a third, situated to the east. They confirmed the fact that the Wai-Tamata did not communicate with the western sea; but they repeated several times, and in a positive manner, that in following the course of the Wai-Mogoia one arrived at a place only separated by a very short distance from the banks of the Manou-Kao [Manukau], a large port situated on the west coast of New Zealand.

This information appeared to me so important that I instantly conceived the project of verifying its truth. I immediately proposed to Rangui to remain on board with Tawiti, whilst I sent some one of our officers to Manoukao under the escort of his warriors. He consented with such good grace and with such an open air that I thought there would not be the least danger for my companions. In consequence, I let go the anchor at no great distance from the place where we had passed the night; and afterwards, at 6 a.m., the whaleboat, under the orders of M. Lottin, accompanied by MM. Guilbert, Gaimard, Bertrand, and Faraguet, departed. A guide supplied by Rangui was charged to conduct them, and to make them respected in the name of that chief.

M. Lottin had orders to proceed as far as Manoukao to reconnoitre the western sea, but so arranging his proceedings as to return by night. The greatest care on their part, in their dealings with the Natives, was impressed upon them. Too many fatal catastrophies, dating from the discovery by Tasman up to the taking of the "Boyd" at Wangaroa [Whangaroa, 1809], have sadly signalised the presence of Europeans in these parts for me to be perfectly tranquil as to the disposition of these people, as easy to irritate as they are barbarous in their vengeance.

At the same time I sent the yawl, under the orders of the boatswain, to obtain wood on a little island adjacent, named Koreha [Motu-Korehu;

Brown's Island]. Its summit is in form of a crater, and the scoria found at its base attests that its origin is equally volcanic, although it is to-day almost entirely covered with a thick carpet of very green herbs.

Rangui had breakfast with me, and comported himself decently at table; afterwards he sent all his people and the canoes ashore, remaining alone with Tawiti on board. Amongst the things which he told me, the following are what I noted with much care: He had no knowledge of any but three vessels that had visited these parts before ours- viz., the "Koroman" ("Coromandel," Captain Downie), "Pateriki" (without doubt, from what I afterwards gathered, the "Saint Patrick," with M. Dillon): lastly, the "Louisiann," which I supposed to be an American. [Major Cruise, in the "Prince Regent," was in these parts in 1820.] This last ran aground and nearly perished in trying to pass through the Paku [Pakihi] Channel. The district of Tamaki, which lies on the banks of the Mogoia, recognises for principal chiefs Rangui, Kaiwaka, and Tawiti, whilst Manoukao is under a great chief named Toupaia [Tu-paea, a leading chief of Ngati-Tipa, of lower Waikato], whom my two guests called their father. No doubt this is only a title of respect or adoption, since they explained later that their true father was Houpa [Te Haupa], a powerful chief formerly established near the mouth of the Wai-Kahourounga [probably Kauaeranga, River Thames], but who had succumbed, with a great number of his warriors, in an epidemic which they attribute to the anger of the God of the English. [Probably this epidemic is that known as "Te Ariki," introduced by H.M.S. "Coromandel" in 1820, when she discovered the harbour named after her, and which epidemic spread through nearly the whole of New Zealand, carrying off very many thousand people. Mr. Marsden was on board her at the time.] In their superstitious ideas it was the appearance of Mr. Marsden amongst them, and the intercession of that *tohunga* or powerful prophet, that procured for them this terrible affliction; but they could not assign any special motive for that absurd opinion. It is known also that during the whole of his voyages in this country Mr. Marsden lived in the most perfect harmony with these people. However it may be, thenceforth regarding those parts as devoted to the celestial vengeance, the children of Houpa and their companions, placing their old homes under an eternal *tapu*, established themselves more to the north on the left-hand side of the Shouraki Gulf. All that side takes the name of Ware-Kawa [Wharekawa], whilst that on the east retains more particularly that of Shouraki. Waikato, situated at three or four days' journey towards the S.S.E., and where is the arsenal of these people, is commanded by Kanawa [Te Kanawa, who was a leading but not the principal chief of Waikato at that time. Te Wherowhero was the head chief then, and for many years after], and defended by a thousand warriors, who at once march if any news is heard of the arrival of Shongui [Hongi] at the Shouraki Bay. Rangui recounted to me the miserable death of Hihi [Te Ihi, a noted Nga-Puhi warrior], one of the most redoubtable companions of Shongui, who was drowned the preceding year in the same basin where we were then anchored. His canoe had capsized during a violent squall. and his body became food for the fishes—a destiny the most fatal [degrading] in the ideas of this people.

My guest never ceased telling me with emphasis that he had killed and eaten Pomare, showing me with pride his Scotch tunic as a trophy of his victory—*Exuvias indutus Achilles.* [No doubt Te Rangi was present at the death of Pomare, for the former's tribe, Ngati-Paoa, were, with Ngati-Tipa, of Waikato, the principal actors in the affair. But it is always said that Nini, of the second tribe, gave Pomare his *coup de grâce* with a spear.] According to my guest, he was preparing the same end for Shongui if the latter should dare to oppose him. Nevertheless, when I spoke by chance of Rangui, of Paihia, whom I had encountered at Wangari, the boasting of my hero diminished all at once, to be replaced by an inquietude very marked, and which had something of the comic about it. He inquired as to the strength of his enemy, of his projects, and demanded more than twenty times if they would not arrive immediately. All noticed that the news cruelly agitated him, and that he was extremely put out at learning that his enemy was so near. Having asked what would be my conduct in case Rangui--whom he surnamed Touke [his real name was Rangi-tuke] to distinguish him from himself-came alongside the corvette, I replied that, being a friend of all New-Zealanders, I should do him no harm; but that I would not suffer him or any of my guests to be attacked or even insulted on my vessel. I added that so long as Rangui, of Tamaki, and his people were under my protection no harm could come to them. That promise gave him pleasure, and appeared somewhat to calm the lively fears that he entertained. The path that we had followed yesterday I found also led to Manoukao, although intercepted here and there. Kai-Para [Kaipara], the residence of Moudi-Panga [Muru-paenga], celebrated chief of those regions, is only distant three days' journey from Tamaki; and that valorous *rangatira*, who had so long resisted Shongui with success, had finally succumbed under the blows of the latter, and had also, with his warriors, served him as a repast. [Muru-paenga, the one chief of Ngati-whatua, of Waitemata and Kaipara, who for many years had withstood the might of Nga-Puhi, was at last caught, with a few of his followers, at Mahurangi in 1826 by some of the Hikutu Tribe, of Hokianga, and there killed. In the days before firearms he was one of the most noted warriors of the Maori race. In 1807 he inflicted a serious defeat on Nga-Puhi at Moremunui, on the beach a little south of Maunganui Bluff, and several times led expeditions to Taranaki. Marsden, who visited him at his Kaipara home in 1820, gives a pleasing description of this great *rangatira*.]

Kapou-Hoka, of whom Touai [Tui, said to be a brother of the well-known Korokoro, of the Bay of Islands] some years ago showed me the prepared head at Paroa [Bay of Islands], was a brother or elder cousin of Rangui's. I believe that Kanawa, chief of Waikato, was a *toupouna* [*tupuna*] or grandfather of Rangui, and father of Tawiti [this is not quite right; see note at the end hereof], from whence it follows that the latter would be the uncle, not a brother of Rangui. In general these titles of brother, uncle, or nephew, or even cousin, are often confounded amongst these people, and they adopt them as often amongst themselves as did the ancient Romans, adding thus to the confusion.

Rangui could only name six of the principal winds—that is, N.W., *moudi* [*muri*]; N.E., *marangai;* E., *tonga;* S., *hawa-ourou* [*haua-uru*]; W., *touaraki* [*tuaraki*]; and N.W., *kauraki*. He recited to me the whole of the famous chant, the *pihe*, and was much astonished at my repeating it after him by reading it from the grammar [Professor Lee's "Grammar and Vocabulary," 1820]. The chief carried as a sceptre a piece of carved whalebone, which he called a *patou-wairoa* [*patu-paraoa*], which I acquired, as also a fine mantle garnished with dogs' hair, of various colours, belonging to Tawiti. The latter had brought his wife* with him, who carried an infant in her arms, who appeared to be equally cherished by both parents. As we had seen in other parts, the slave girls granted their favours to the first-comer for the merest trifle, whilst the married women were inaccessible. In order to prove the extent of the scruples touching conjugal fidelity, M. Gaimard made all sorts of offers to Tawiti to obtain the favours of his wife; that *rangatira* was deaf to all these seductions, even of the offer of an ordinary musket, and contented himself each time by responding, "*Tapou*" (sacred, defended) [*tapu*]. But when the doctor came to offer, as a pleasantry, a double-barrelled gun, this savage chief, incapable of resisting an offer so seducing, pushed his wife into the arms of the stranger, whilst he held out the other hand for the gun. Before judging too severely these children of nature, it must not be forgotten that in their eyes an arm of that kind is to-day a greater prize than a chamberlain's key, a marshal's baton, or even a Minister's portfolio, in the eyes of a European.

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* See pl. lvii.

As I had already remarked in similar cases at the Bay of Islands, the wife of Tawiti showed the greatest repugnance to part with a shark's tooth which she carried in her ear. The only reason she offe ed was that this tooth came from a stranger (*tangata ke*), a response which had often been made to me at Paroa. It must follow that these Natives hold singularly to souvenirs of friendship which have been left them, if, indeed, it is not the effect of a superstitious sentiment.

At 5 o'clock the canoes returned alongside, bringing an immense quantity of fish. These islanders ceded them to the sailors for scraps of biscuit, and showed great probity in their bargains. The yawl brought two loads of wood, which was easily procured from Koreha Island.

The whaleboat returned at 7.15 p.m. with all our voyagers. After having ascended the Mogoia [Tamaki] River three or four miles, they landed on the shore of a narrow isthmus, which they crossed, and then found themselves on the basin of Manoukao. They had nothing but praise for the proceedings of the Natives, and were received by them with all possible honour. I refer the reader to M. Lottin's account* for details of this interesting excursion, and the results of his explorations; for the rest, it is now proved that the island of Ika-Na-Mawi in that part is reduced to a very narrow tongue of land [at Otahuhu].

This discovery may become of great interest for any settlements which may take place in the bay of Shouraki, and the interest augments the more if further reconnaisances demonstrate that the port of Manoukao is susceptible of receiving ships of a certain size, for such an establishment would thus be found within reach of the two seas, both east and west.

Toupaia [Tupaea], the principal chief, could not come on board till the morning; but Inaki, *rangatira paraparao*,† who had received the gentlemen at Manoukao, accompanied them on their return. He was of medium height, but very well built, with an expressive face and proud attitude, and a truly warlike air. He appeared to be altogether independent of Rangui, who on his side affected to treat him with haughtiness. The latter did not cease to repeat that Inaki was much inferior in rank, and that he was but a *rangatira paraparao*, allowing also that he was a very brave warrior. I concluded that, as in other countries of the globe, Inaki, though inferior to Rangui by birth, had perhaps acquired by his courage and his exploits the right to command the warriors of Manoukao. He presented me with his baton of command, carved at its extremity, incrusted with shell, and enriched with precious plumes. [Inaki must not be confounded with Hinaki, the principal chief of this branch of Ngati-paoa, who was killed at the storming of Mauinaina or Mokoia Pa, near Panmure, by Hongi's war-party in 1821. Hinaki was the father of Harata, wife of old Epiha Patene (or Jabez Bunting), well known to old Auckland settlers. *Paraparau* means "one captured in war," and, as often happened, probably Inaki, by his courage as a warrior, had risen to be a leader in war in his captor's tribe.]

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* Note 16 [at the end hereof].

† A title which corresponds to that of first lieutenant of the principal chief, and confers on him the function of chief warrior.

Te Rangui had become altogether my guest, and slept in my cabin, whilst Inaki and Tawiti were treated on the same footing by the officers. Rangui was extended tranquilly on his mattress, and was preparing to sleep, when he heard in the adjacent cabin (the officers' quarters) his two companions occupied in negotiating the introduction of some women who had been demanded of them. My chief then demanded of me if I also wished the same; on my replying in the negative he heaved a sigh; subsequently, supposing me to be asleep, he stole away softly, and went to take part in the negotiations of his two companions, in order, no doubt, to participate in the profits which should accrue to them.

27th February. - At 5 a.m., desiring to profit by a light breeze from the S.S.W. to continue our work, I had the topsails set, and half an hour afterwards we were under way to the E.S.E. towards Pakii [Pakihi].

Our noble friends, Rangui, Tawiti, and Inaki, before leaving us, promised to return and see us at Shouraki. By means of a ribbon I suspended round the necks of Rangui and Inaki medals of the expedition, in sign of protection and friendship, testimony of which they appeared very sensible. Rangui having informed me that the passage by Pakii was not safe, and that it was necessary to take another, between the islands, offered me one of his slaves (*kouki*) [*kuki* -*i.e.*, cook] to serve as pilot, assuring me that the man knew all those localities perfectly. In testifying my thanks to the chief for this mark of attention, I was little disposed to place too much confidence in the nautical knowledge of such a person, who, after all, could never have piloted anything but a canoe, drawing only 2 ft. or 3 ft. of water.

At the time when the chiefs embarked in their canoes, an incident occurred showing the character of these people. I have already said that during all the time the corvette was at anchor off the Mogoia River, not only Rangui and the other *rangatiras* had comported themselves with propriety, but also their subjects had trafficked alongside with a good faith worthy of praise. As we got under way I was told that one of the Natives had taken the lead of the sounding-line, negligently left hanging in the chains. Taken in the deed, he returned it without any resistance, and hastened to slip away. Addressing Rangui in a loud voice, and with a severe tone, to the effect that they were not worthy of being called honest men, I said that we would chastise robbers without mercy. That reproach and threat appeared to affect him profoundly; he excused himself by saying the crime had been committed without his knowledge by a stranger, a slave. Then, with a submissive air, he demanded if I intended to punish him for that action. I responded that it was of no consequence this time, and wished him good-bye in a friendly way, and turned away to the work of the ship. An instant after, the noise of heavy blows and of pitiable cries coming from the canoe of Rangui drew my attention to the side. Then I saw Rangui and Tawiti both striking a mat which seemed to cover a man.

But it was easy to see that these two astute chiefs were only striking the side of the canoe. After having played this farce for some time, Rangui's paddle broke, and he nearly fell over; and he, calling to me, said that he had nearly killed the man, and demanded if I was satisfied. I responded in the affirmative, laughing to myself at the ruse of these savages—a ruse, moreover, of which examples are to be found amongst many people more advanced in civilisation.

Rangui and his companions had often urgently demanded lead to make balls with, a request which I was not able to comply with, because we had hardly enough for our own use. Without doubt, it was impossible for that chief to resist the temptation of possessing such a large piece at once, and it was by his orders the lead had been taken. Seeing the larceny discovered, he had not hesitated to leave the slave to bare the blame, and resolved to appease my anger by a pretence of giving me satisfaction.

The feeble and variable wind only allowed us to advance very slowly, with a depth of from 5 to 6 fathoms, along the pretty island of Wai-Heke. In approaching the pass, I sent M. Guilbert to sound the Pakii Channel, and presently the red flag which he hoisted announced that he had found less than 4 fathoms. I then decided to proceed along a channel to port, and which my pilot Makara assured me was practicable for our corvette. This new channel has not more than half a league of width, and is also confined by an islet (Takoupou) [Takupu], situated towards its middle. I passed by the northern arm at less than two cables' length from that rock, and not having for a long time more than 4 fathoms under the keel, which caused me some anxiety. Presently the depth increased to 7 and 8 fathoms, the breeze became fresher from the west, and we sailed rapidly along these unknown channels. A pleasant vegetation decorated their shores, offering to us at each instant the most agreeable effects of perspective. It was thus we navigated during nearly two hours, by islands, sometimes high, broken, and covered with magnificent forests, sometimes lower, and carpeted only with a more modest verdure.

There is no doubt that it would be easy to find in these agreeable islands places well suited for settlement. I remarked particularly on the shores of Wai-Heke places that seemed to me admirably suited for such establishments. It is vain to repeat that I deeply regretted having to leave these beautiful places without power to explore them more attentively, and without levying a new tribute from all the natural productions. But time pressed, and other work called us far from these coasts.

I must say that our guide, Makara, in that difficult navigation, showed a coolness, an attention, and an intelligence which would have done honour to a European pilot. I never found his directions at fault; it was a spectacle as new as it was interesting to us to see a savage, a cannibal, take us through these solitary channels like an attentive and devoted pilot. He gave me the names of the islands and adja ent lands with much complaisance. If I had been better able to understand his language, no doubt I should have acquired many important details. He informed me that it certainly was the god of the white people who had killed Houpa [Haupa] and the other inhabitants of Shouraki. When I asked who was the god of the white man, he pointed to the binnacle; and it was not for the first time these Natives had accorded divine honours to that singular machine, so much above the intellectual sphere of a poor savage.

At 3 p.m. we entered into the Shouraki Bay, a lit le to the south of the place which Cook named "The Isles of the West." With a unanimous voice we gave the name of our ship to the fine channel through which we had passed in all its extent, and explored with so much success. If one wishes to estimate it, starting from the island Tiri-Tiri-Matangi, where our discoveries really commenced, the Astrolabe Channel has not less than fifty miles in length; but by making its origin at Rangui-Toto, where, restricted between the two shores that approach one another very nearly, it offers at all times the best anchorages in the world for ships of all dimensions, and from there it presents a development of nearly thirty miles of coast, without including the Wai-Tamata branch, to which we were unable to assign the real extent. It is undoubted that one day these channels will play a most important *rôle* in navigation, when the Colony of New South Wales shall take on the development it is susceptible of. The work of the "Astrolabe," until then disdained, will revive in the memory of man like that of M. D'Entrecasteaux, which already interests an entire colony established on the places which that navigator found originally a complete desert [no doubt the author refers to Hobart].

At a mile outside where the Astrolabe Channel joins Shouraki Bay is an isolated rock, altogether bare, wild, and inhabited by myriads of cormorants. The people have given it the name of Tara-Kai (from *tara*, cormorant; and *kai*, to eat) [Tarakihi]. We made a "station" close to that rock, and afterwards pursued our route to the south, with a light breeze from the S.W., changing to the south at 6 p.m., which constrained us to anchor in 6 fathoms at less than half a league from the coast of Ware-Kawa [Wharekawa], and near a somewhat remarkable cape named Wai-Mango [probably near Orere].

28th February.—The night was fine and tranquil. The following day, at 6 a.m., the "Astrolabe" was under sail, and I endeavoured to approach the mouth of the Wai-Kahourounga [Kauaeranga, at the Thames]. But the breeze, which at first was E.S.E., varied successively to the S.E. and even S.S.W.: this caused me to renounce the project of advancing towards the head of the bay, and at 8.30 a.m. I again anchored in 8 fathoms, mud, at about two miles from the shore, and at seven miles and a half from the mouth of the river [Thames]. From the anchorage we could distinguish clearly the two points of the entrance; but the head of the bay is no doubt nothing but an alluvial plain, and is so low that it was only from the tops that the immense forests of *Podocarpus* that cover a large part could be seen. As soon as the corvette had anchored, I sent M. Lottin to the adjacent coast to make a geographical "station," and at the same time to leave our excellent pilot Makara. Although belonging to the slave class, or *kouki* [*kuki*, derived from the English cook], this young fellow had, by his conduct on board, merited our esteem. In parting with him, I gratified him with a packet of powder, a large axe, and some other trifles, which made him the happiest of men. He spared neither pressing nor promises to determine me to return and see his chiefs, who were about returning from Waikato with immense provision of hogs, potatoes, and kumaras. Much as I should have desired to prolong my sojourn in these interesting parts, the time pressed, and the "Astrolabe" had to visit a number of other places besides New Zealand.

In consequence, as soon as the boat returned, we got under sail, and directed our course towards the Shouraki coast [east coast], to follow it closely. It is much more elevated, and, moreover, more abrupt, than that of Ware-Kawa, and the ground is not suitable for cultivation. We may remark here that the place where M. Lottin had debarked he found a shore of pebbles on which the sea broke, and beyond that a marsh, impracticable, and covered with *Phormium*. In general, this part of the Shouraki Bay cannot compare in appearance and fertility of soil with the shores of the Astrolabe Channel.

At 6.20 p.m., the wind having passed to the N.N.E., and the current turned towards the head of the bay, we anchored in 5 fathoms, two miles from the shore. All day we had seen a great fire on the Shouraki side; but no canoe came out to us, which proves that the tribe inhabiting that district is poor and not numerous. [The fact is that the Ngati-Maru and other tribes owning this part of the Thames district had mostly been driven to the upper Thames by the constant incursions of the Nga-Puhi.]

1st March.—A fresh breeze from the east blew all night, which we profited by at 5.20 a.m. to continue our route, following the coast two or three miles distant, so as to seize on all the details. At noon we made a "station" on the parallel of the northernmost of the Islands of the East, of Cook, the Wai-Hao [Waiau, probably—*i.e.*, Coromandel Harbour], Wai-Mate [Waimate], Papa-Roa [Paparoa, which is a place on the mainland five miles north of Coromandel], and Moutou-Kawao [Motu-Kawau] in the Native language. These islands would offer excellent anchorages, as also would several well-marked bays along the coast. This latter rapidly rises everywhere in escarped mountains covered with forest. The summit, Moe-Hao [Moehau],* which ends in the cape of the same name (Cape Colville of Cook), is remarkable for its elevation. All this land seemed to us uninhabited, and we saw no other smoke but that of which I have already spoken.

We had charming weather and a smooth sea; but the breeze, which was feeble, only allowed us to advance slowly. All the same, we succeeded in getting to the north of the channel formed by Cape Moe-Hao and the island of Otea [Aotea]. We passed at five miles an island in the channel [Takapau, otherwise Te-poito-o-te-kupenga-o-Taramai-nuku !], and at 6 p.m. were about mid-channel between Shoutourou [Hauturu] and Otea. The calm surprised us in that place, and we were obliged to pass the whole night directing all our efforts to avoid falling on one or the other.

Every time we were becalmed the crew caught with lines an astonishing quantity of fine fish belonging to the species *Dorade unicolor*, which are excellent eating. It is the same fish that Cook calls "bream," and appeared to be prodigiously abundant in these parts. Whilst we were at anchor off the Mogoia [Tamaki] River, the Natives of Tamaki loaded their canoes in the space of a few hours. To-day the crew soon caught hundreds, and there was enough to supply each plate with ample provision.

2nd March.—At 2 a.m. we found that the current had taken us near to the coast of Shoutourou [Hauturu, or Little Barrier], and afterwards carried us towards the strait of Moe-Hao. At daylight the calm still prevailed, and we were obliged to remain in the same position. The channel which separates the two islands of Shoutourou and Otea has a width of seven or eight miles, and appears very safe, with regular soundings of 30 fathoms. Shoutourou rises rapidly on all sides up to a conical mountain of a considerable height, and is easily seen from all parts of Shouraki Bay [Hauraki Gulf]. The surf breaks all round it, rendering it difficult for small boats to land. It is the same with Otea, of which the coast is even steeper, cut up with gullies, and often devoid of vegetation; nevertheless, ships would probably find shelter under the little islands situated near the larger one. At two or three miles to the south of the west cape of Otea, which we named Cape Krusenstern, is a little group of bare rocks, which at a distance have the appearance of canoes under sail, which caused us to give it that name.

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* [The Geological Department, quite wrongly, call this mountain "Te Moehau," which is not the name given to it by Tama-te-Kapua, captain of the "Arawa" canoe, *circa* 1350. There is no "Te" in the name.—TRANSLATOR.]

3rd March.—A light breeze from the S.W. having arisen, we profited by it to advance on our route towards the north. At midnight, being then about three miles to the east of the island Moko-Hinou [Mokohinau, also Poko-hinau], I laid to to await daylight. Afterward I steered as much west as possible, to regain the coast near Wangari, to continue the explorations ended some days before near that point. But the wind remained in the west, and I was reduced all day to beat to windward to approach the coast. . . . .

[We may leave the "Astrolabe" here, with the hope of being able to take up the narrative of her visit to the Bay of Islands on another occasion.

[With respect to the Natives seen at Tamaki by D'Urville, these were members of the Ngati-Paoa Tribe, who originally owned all that district. D'Urville did not, as might be expected, get the exact relationship of the chiefs whom he met there. Te Haupa (or Kaiwaka), a great chief of that tribe, was a son of Toto-ka-rewa, as was Tawhiti (or Waero). Rangi is not known, unless he was Tawhiti's son Rangi-pua. These people had a few years previously been driven from their homes by Nga-Puhi, under Hongi, who had inflicted a disastrous defeat on them at the taking of the pa, Mauinaina, situated just across Mokoia basin, to the south of Panmure, in 1821. The people that D'Urville saw only visited their old homes occasionally to procure fish, &c., for they had migrated to Waikato in order to avoid the constant raids of Nga-Puhi. A few months after D'Urville's departure from the Tamaki, the expedition that he saw at Whangarei, under Rangi-tuke, met the Ngati-Paoa just inside Tamaki Heads, and a great battle ensued, in which Rangi-tuke and all but about twenty of his followers were killed. The Ngati-Paoa in this case were assisted by the Ngati-Tipa, of Waikato Heads. All the details of these troublous times will be found in "Maori Wars of the Nineteenth Century."]

NOTE 16.—M. LOTTIN'S JOURNEY TO MANUKAU.

. . . . At 9.30 a.m. I left in the whaleboat with MM. Guilbert, Gaimard, and Faraguet. We were about to ascend the Wai-Mogoia and verify the assertion of the Natives who affirmed that in that part New Zealand could be crossed in a few instants, and then we should arrive at the sea which bathes the west coast.

At 11 a.m. we entered the river. Above its mouth, confined by a tongue of sand, it forms a large basin of a mile and a half in width by two in length, where the water is salt; and beyond that, at low water, banks of mud appear, obstructing its course, and reducing it to a sinuous channel, of which the width varies from 50 to 200 toises, and is only navigable by small boats.

By noon we had crossed the first basin, and the water became drinkable. The sinuosities of the river caused us to pass near a village, or sleeping-place (*moemoe*), situated on the right-hand shore, and named Ourouroa [Ururoa]. An immense quantity of fish was drying in the air, extended on frames, and exhaling an insupportable odour. The Natives gathered on the summit of the cliff, drawn thither by curiosity, and talked with loud voices to our guide as long as the speed of our boat allowed, whilst many children followed us along the banks.

As we advanced the land became lower; it was covered with tall vegetation, and cut up by small streams of almost stagnant water; many isolated mounts of no great elevation dominated the plain, recalling the tumuli of Greece.

At 12.15 the river suddenly terminated in a basin 200 toises wide, and beyond it there was nothing but a streamlet of water. We disembarked on the mud, leaving M. Faraguet to guard the boat. We were at this time seven miles from the corvette and about three miles and a half in a straight line from the mouth of the Mogoia, the general direction of which is S. ¼ S.W. to N. ¼ N.E.

At 12.55 we took a path cleared through high vegetation, which appeared to be frequently used by the Natives. The lay of the land prevented our seeing very far ahead, but at 1.50 p.m. we found ourselves on the borders of the sea of the other coast. We had therefore taken fifty-five minutes to cross New Zealand, which in that place had only about two miles of width. [It is clear from this account that M. Lottin did not go to the head of the Tamaki at Otahuhu, but crossed the Mokoia basin south of Panmure and came out on the Manukau north of Mount Richmond.] We now had before us what appeared like an immense lake. We tasted the water, and found it salt; and, noticing a hill near us, we directed our steps towards it, with the intention of obtaining a more exact idea of the locality. A canoe was out fishing. The piercing vision of the Natives soon discovered us, and they immediately paddled ashore, and directly afterwards a numerous and armed crowd surrounded us. After talking some moments with our guide, the noisy escort accompanied us to see the chief of these parts.

We passed near some huts which exhaled the odour of rotten fish. There was no palisade to protect them; it was a kind of flying camp, ready to be quitted at the first announcement of an enemy. Many young girls came forth and joined our party, whilst a crowd of children gazed at us most earnestly, notwithstanding the blows from the butt of the guns which our escort seemed proud to bear. Presently we saw the chief; it was Inaki, one of these handsome New-Zealanders. He commanded under him who owned that part of the island, having the title of *rangatira-paraparao*, general-in-chief of the warriors. He was advantageously posted on the upper part of a slope at the extremity of a double rank of his warriors, and clothed in a beautiful mantle of dog-skin. He stood upright, supporting himself on a spear ornamented with plumes and tufts of hair. I made him a present of some cloth and a medal of the expedition, which had been given me by M. D'Urville for that purpose. The guide explained our intentions, and he gave us his permission to climb the hill, which is sacred, and up which, as a matter of fact, none of the Natives followed us. [This was probably Mount Richmond, formerly a pa, possibly at that time used as a burial-ground.]

Arrived at the summit, we were disappointed in not being able to see the entry from the ocean. In the place indicated by the Natives towards the west was a well-pronounced depression in the mountains which bounded our view, but an island between them and us prevented our seeing as far as the ocean. [This would be Puponga Peninsula.] The immense bay seemed entirely safe; but near the shores many mud-banks appeared, showing that there would be a good bottom for anchors. We took a few bearings to give more exactitude to our sketches, and then descended, urged by the advanced hour, which prevented us taking a more interesting course by boat.

The Natives give the name of Manoukao [Manukau] to this bay. They stated a hundred times that it communicated with the open sea, and I have no doubt on the subject. It is probable that it is the False Bay of Cook.

We distributed several articles of hardware and some small pieces of French money, and then departed with Inaki, who expressed a desire to see the commander.

We traversed rapidly the narrow isthmus which separated us from the boat, and, catching part of the ebb tide, returned very slowly down the Mogoia River. A great number of Natives were collecting shellfish on the mud, and the rocks at the entrance were covered with fishermen. We reached the "Astrolabe" during the night.

Art. LII. *Maori Forest Lore: Being some Account of Native Forest Lore and Woodcraft, as also of many Myths, Rites, Customs, and Superstitions connected with the Flora and Fauna of the Tuhoe or Ure-wera District.—Part III.*

By Elsdon Best.

[*Read before the Auckland Institute, 22nd November,* 1909.]

The Lore of the Whare Mata.—The Art of the Fowler.

The *whare mata* was a house set apart in each of the principal villages of a tribe for the making of snares, traps, and all other implements pertaining to the taking of birds and fresh-water fish. For Tuhoe are essentially a forest tribe, and possess no seaboard. The *whare mata* and its inmates, the forest craftsmen, were under strict *tapu* while engaged in preparing the above implements and until the *tapu* was lifted or abolished at the first-fruits rite. Neither women nor food were allowed within the portals of this house. But of this more anon.

In like manner all matters pertaining to national or tribal history, religion, genealogies, &c., were taught in a special house known as the *whare maire*, *whare puri*, or *whare takiura*. The art of weaving is the art of the *whare pora*. Mourning for the dead pertains to the *whare potae*, or house of mourning; while all games and amusements come under the heading of the *whare tapere*.

We will now proceed to give some account of the fowler's art, the preserving and taking of birds, and of some singular customs, rites, and beliefs connected with the forest and its denizens. The methods by which some birds were taken have already been given, but the bulk of such matter lies yet before us, albeit the most of it pertains to the taking of but two species, the *kaka* and the *kereru*—the brown parrot and the wood-pigeon. These were the two most important species of forest-birds from the Native point of view, because they furnished the most food for man.

Birds were most strictly preserved in former times that is, no person was allowed to take them out of season save under extraordinary circumstances. To trespass on lands of another tribe, subtribe, or even family group spelled swift trouble and ofttimes death to the offender. Both fish and birds were sometimes specially protected by means of the custom termed *rahui*. There were two forms of *rahui*, one being a mild form of prohibition imposed by the owners of the land. To disregard this was not particularly dangerous to life, unless possibly the trespasser encountered an owner of the land while poaching. This form of *rahui* was not in itself dangerous. But another form was so, because it was accompanied by spells of black magic that would slay a poacher as surely as does the spear or club. In some cases a material token of the *rahui* would be set up by the stream or in the forest; in others no such token would be employed, but the prohibition would simply be published by word of mouth, together with a description of the prohibited area—perhaps a part of a certain river, or the lands of a certain family group or clan. The more severe form of *rahui* was established by a *tohunga* (adept, priest, shaman) by means of a religious rite performed by him at a sacred fire specially generated for the purpose. He recited certain spells of black magic to endow the material token of the *rahui* with power to destroy poachers. A description of this custom and rite may be found at page 83 of vol. xiii, "Journal of the Polynesian Society."

The act of violating a *rahui* is termed *kairamua*. Of a stream or forest so protected it is said, "*Kua tu rahuitia* te wai," or land, as the case may be. In some cases *mana tangata*, or personal prestige, was sufficient to enforce and uphold a *rahui*; if not, then black magic would be employed.

Poaching, or taking game on lands to which the trespasser has no claim or right, is known as *kai haumi*, and *kai haumi* is a serious crime, or was so in former times. Travellers were sometimes guilty of this offence, and were in many cases attacked by the people of the land. But if such travellers informed the owners of their act and handed over some of the game to them, they would then be allowed to proceed in peace, for by so doing they blunted the edge of the offence and acknowledged the rightful owners. An oft-quoted ancestor is one Tamatea-kai-haumi, who is said to have been addicted to poaching game. He is said to have been also known as Tamatea-mai-tawhiti, and is supposed to have come to New Zealand on the Nukutere canoe.

If feathers were seen lying on a trail or in the forest, it would be known that a poacher was at work. He would be pursued, and slain if caught, unless a relative to the pursuers. Or some of the feathers would be taken to a master of black magic, who would use them as a medium between his spells and the victim, and so destroy the *kai haumi* villain. Those scattered feathers were a sign of a poacher's presence, because no old-time Maori would permit any feathers of trapped or speared game to so lie on the ground, be he never so far in the forest—that is, on his own lands. For, were he to do so, the birds would desert those lands and migrate to other parts. Old Tutakangahau, a man of much curious knowledge, and with all the lore of Tane at his fingers' ends, said, "The feathers of birds were always buried. If they were not so disposed of, then the birds would leave the district. When feathers were seen lying about bird-troughs, or any snaring-place, they were carefully collected and buried. Feathers are *tapu*. If a dead bird were found anywhere it would be buried by the finder. If a person saw some feathers on the ground -feathers that had been plucked out by the birds themselves, any dropped feathers—then such person would return home and say, 'The birds have migrated; there are none left.' Then it would be asked, 'How so?' And he would reply, 'I saw the feathers.' Old people would be very angry if they saw feathers lying about a village. Now, suppose a man is engaged in trapping birds. He snares a bird, and at once plucks out the long feathers from the wings and tail. He forms these feathers into a bundle, and throws it down at the base of the tree he is perched on. If he is down on the ground trapping birds, he will thrust that bundle of long feathers under the tree-fern fronds of which his shelter is constructed —*koi hautea te huruhuru, koi heke te manu* (lest the place be whitened by feathers, lest the birds migrate). That is the reason why all feathers are buried or concealed— *koi hautea te huruhuru, koi katea haere i te ngahereherc, koi putu haere* (lest the feathers be whitening the forest, lest they be seen lying about). It was a common thing to hear a person say, '*Kaua e whakahautea te huruhuru*'; or an old fowler to young people— '*Koi hautea te huruhuru.*' "

Here we see that it was considered absolutely essential that no loose feathers should be seen in the forest, or on paths, or even at the villages: they must be buried or otherwise concealed. You cannot be too careful during the game season, or you will find your forest birdless. There is much *tapu* pertaining to the offspring of Tane, arboreal and ornithological, and unless you have a care you will offend the forest gods and bring trouble —yea, dire tribulation—upon yourselves. It makes you careful, you know.

And here is another point. Paitini, of Tuhoe, says, "During the birding season, should we go to a village and there be given some birds as food, we might not consume them all, and so be desirous of bringing home those not eaten, but we would not be allowed to do so. We must leave them there, because if cooked food be carried through, or taken into, the forest during the game-taking season, then the *mauri* of the forest would be polluted, defiled; the birds would leave the forest, and then there would be no birds (*kua tamaoatia te mauri o te ngahereherc, kua heke nga manu, kua kore he manu*)."

Here again old Tutakangahau explains: "A person, or a party of persons, goes to a village. They arrive, and are given food—cooked birds— and do eat thereof. But they must not take away any of those birds, or any remnants even of those partially consumed by them. But if they are given any uncooked birds, they may take those. But still one of those uncooked birds must be returned to the donors, the villagers, as a *tautawhi*— that is to say, one bird will be taken by the villagers out of the *mata* (basket of birds) presented to the visitors. *Tautawhi* means a holding, a retaining of the birds (of the forest), lest they follow those given to the visitors, and which will be taken away. The village people will take that one bird from the basketful, or they may merely take a wing of one of the birds, just break off a wing as a *tautawhi*. As a person takes the bird or wing he repeats,—

"Puritia a uta
Puritia a tai
Puritia a Tane.

(Retain [the products of] land and sea; retain Tane.) That is all. He takes the wing away and buries it in the earth, but the body of the *tautawhi* bird will be eaten by the villagers."

Tautawhi, or *tautaawhi*, here implies holding or retaining the feathered denizens of the forest, lest they leave the forest. *Tamaoa* means "to deprive of *tapu*, to pollute or defile by means of cooked food," which same is a most soul-destroying thing according to Native ideas. No cooked food may be taken into the forest during the game-taking season. Such an act would destroy the *tapu* of Tane and his offspring, and impair their vitality and the productiveness of the forest.

THE MAURI OF THE FOREST.

We must give some explanation of the *mauri*, an expression often met with in Native forest lore. The *mauri* or *mauri ora* of a person may be termed the soul, in one sense, inasmuch as it represents the vital spark, the spiritual, intellectual, and even the physical well-being of the *genus homo*. Should the *mauri* become in any way defiled or polluted, the consequence is that the person is left in a dangerously defenceless condition, exposed to countless dangers, physical and otherwise. The protective divine spark is quenched, the vitality is impaired. In some ways the *mauri* of a person resembles the *hau*, which latter is the very essence of vitality. If a person's *hau* be taken and brought under the influence of black magic, then death comes swift and certain. But it is not the real *hau* that is so taken—merely something to represent it, to act as a medium in sympathetic magic, such as a portion of the person's clothing, or hair, or spittle. This medium is termed a *hohona* (*hohonga*) by the Tuhoe people, but *ohonga* by other tribes.

Now, the *hau* and *mauri* pertain not only to man, but also to animals, land, forests, and even to a village home. Thus the *hau* or vitality, or productiveness, of a forest has to be very carefully protected by means of certain very peculiar rites, otherwise such forests would lose their vital functions, their vitalising power, their life-principle. In a word, the *hau* is the sacred life-principle of man, land, forests, &c., and if lost or polluted, then disastrous are the consequences. For fecundity cannot exist without the essential *hau*.

Now, in regard to the forest, it will be found that the *mauri* of a forest is a term applied to the material token selected by the owners of such forest in order to represent the vital spark, productiveness, life-principle—in fact, the *hau* of the forest. This material token is placed at some selected spot in the forest. It is carefully concealed, and also protected by means of certain rites and incantations. Certain rites are also performed over it by tribal priests in order to endow it with the necessary powers, sacredness, &c., to represent and protect the *hau* of the forest lands and the denizens thereof. If this *mauri* be discovered by tribal enemies, they will assuredly, by means of certain rites and charms, destroy its powers, thus bringing much trouble on the owners of the forest, who probably rely on such forest for a large part of their food-supply.

Ngahooro, of Te Whaiti, a very old man, said, "The *mauri* of a forest is usually a stone. It is carefully concealed, lest it be found by an enemy. If placed at the base of a *tutu* tree (a tree on which birds are taken by the *mutu* system), then birds will frequent that tree in great numbers. Only a *tohunga* could discover a *mauri* when so concealed; no ordinary person could do so. A small platform (*kahupapa*) would be constructed among the branches of such a tree as a stand for the fowler. In some cases a *moko tapiri* was kept under such stage, in order to guard and take care of the tree."

The Maori looks upon several species of lizard with superstitious dread, believing them to be endowed with strange powers: hence the placing of a live lizard in some hollow place of a snaring-tree.

Paitini says, "The *mauri* represents and protects the land and the birds of the forest. If persons of another tribe come along they cannot interfere with the land or meddle with the birds, because the *mauri* is hidden. But should they discover the *mauri*, then they would be able to do these things."

By "interfering" and "meddling" the old man meant that such persons would be unable to render the forest unproductive as to birds, fruits, &c., or to drive the birds away, by magic rites, so long as they did not discover the *mauri*.

It will be seen that the *mauri* of a forest acted as a talisman in protecting the land, forest, and all forest and stream products. The *mauri ora* is the living soul, the soul of life, of man, land, and many other things to which the term is applied. The *mauri ora* of the Matatua vessel was kept at Whakatane. Its visible form is said to have been a piece of fern (*makaka* or *rarauhe*).

Tamarau Waiari said, "The *mauri* of a forest is often a *kira*—that is, the left wing of a *kaka*. This wing, together with a stone, is concealed at the base of a tree. Sometimes a lizard is placed there to guard the *mauri*. Now, should some unauthorised person wish to poach on such lands—that is, to snare or spear birds there—he would first endeavour to find the *mauri*. If successful, he would then be able to take plenty of birds. When searching for the talisman he repeats a charm known as *kahau*, which runs,—

"Ka hau ki uta,
Ka hau ki waho.

After repeating the above he listens intently, and if he hears no sound he turns and faces in another direction, again repeating the charm. Should there be no response, he turns in yet another direction and tries again. If he happens to be facing in the direction of the spot where the *mauri* is hidden, then the lizard answers the charm by making a chattering sound. Upon hearing this the talisman-seeker completes his charm:—

"Tohi mauri, tohi tia ki
Wetekia te hau e here nei i te mauri
Homai ki au kia whangaia
Ki te toa, ki te ruahine."

In the above we see that a poacher on tribal preserves would endeavour to find the *mauri* of such forest. If he wished to take birds on this land he would search for the *mauri*, so as to insure success, because it was a custom to offer the first bird snared at the shrine of the *mauri*. This was to bring good luck.

If the trespasser simply wished to cause the birds to desert the forest, and perhaps to decoy them to the lands of his own people, he would still wish to find the *mauri* in order that he might nullify its virtue and powers. Paitini says that *kira* (the "i" sounded long) means the long feathers (primaries) of a bird's wing (perhaps of the *kaka* only), and that the *kira* of the right wing only are used as a *mauri*; those of the left wing have no *mana* (innate power of influence). He also said (8/3/1897), "This object, the *mauri*, is for the purpose of holding, retaining, the *hau* of the tribal lands, of the village home, of the forests and streams and the denizens thereof. Only a very few persons of a village community were taught how to preserve the *hau* of the home and lands; the bulk of the people were ignorant of such functions. Now, if a *tohunga* (wizard, shaman) of another tribe came along with the intention of destroying the *hau* of our lands, &c., he would not be able to accomplish his object, the *hau* would not be destroyed, because the *mauri* would be concealed, hidden in the forest. Such *mauri* was often the *kira* of a bird of the *kaka* only, because that is the most important bird. The *kaka* is the bird that brought the *mana* of Hawaiki to this land. The *tohunga* (adept, priest) would endow the *mauri* with its powers by means of certain rites and charms. This *mauri* would preserve and protect the birds and cause all food products to flourish."

A *mauri* sometimes consisted of a hollow stone, in which hollow would be placed a lock of hair or some other item. These articles would be deposited at the base of a tree, hidden in a hole, or by the side of a stream.

"The term *hau*," says Mr. Percy Smith, "is used in Polynesia to imply 'dominion over,' or 'ruling power, protecting power.' It is applied to a high chief's reign, sometimes to the high chief himself."

The following notes on the *mauri* and *hau* of a forest were given to me by Tamati Ranapiri, of Ngati-Raukawa, a man who possessed much curious knowledge pertaining to Native forest lore :-

"The *mauri* is a *karakia* (ritual, formula) recited by a priest (adept) over a stone, a piece of wood, or some other object approved of by him as a shrine, refuge, or abiding-place for the *mauri*. The force or powers of the *mauri* are implanted in such object, which is placed in some secluded spot in the forest and there left. This forest *mauri* never becomes *noa* (free of *tapu*, common). Also, it is not the case that the whole forest is as intensely *tapu* (sacred, under religious restriction) as is the spot where lies the *mauri*.

"There are two aspects of the *hau* of a forest. Firstly: When certain persons go into the forests to see if birds are numerous and in good condition for taking, and they take some birds on such an occasion, then the first bird taken by them is given to the *mauri*. This first bird is simply cast away in the forest, with the remark, 'That is for the *mauri*.' This is to insure a good bag, to avert non-success, to prevent bad luck afterwards. Secondly: When the fowlers cease snaring birds in the woods, and return home, then commences the cooking of the birds for potting for future use. But, in the first place, some of the birds are put aside as an offering to the *hau* of the forest. Such is the forest *hau*. Those birds selected as an offering are cooked at a sacred fire. Only *tohunga* (priests, adepts) may eat the birds cooked at such a fire. Certain other birds are selected to be cooked at the *ahi tapairu*, and only women (of rank) may eat those. The bulk of the birds are cooked at the *ahi purakau*, and the birds cooked at this fire are for the rest of the people."

In the above we see clearly that the true *mauri* is implanted, as it were, in a stone or other object by means of an invocation or charm called also a *mauri*, simply in order to provide it with a shrine, or physical basis. This material object, though called a *mauri*, is not really so, but it represents the *mauri*. Until the rite was performed that implanted the *mauri* therein it was nothing but a common stone.

The offering of the first-fruits of the bird season to the *hau* of the forest is also of much interest.

The *ahi purakau*, or *pu-rakau* fire, is known to Tuhoe, but with a different connection, as we have explained in the first part of this paper.

In response to some inquiries of mine, I received the following from Tamati Ranapiri :—

"Regarding the expression *whakangawha*, it equals the term *whakapakaru* (*i.e.*, to cause to break forth, to disclose, to make known or to test, as used by T. R.). Suppose an adept teaches a person certain rites and charms, those pertaining to black magic and to implanting the *mauri*, and other Native rites, until his pupil becomes proficient. Then the priestly adept will say to his pupil, ' Now test your power.' That is, he would tell him to shatter a stone, or kill a person, or what not, merely by means of a magic charm. Now, if he succeeded in shattering the stone or in killing the person by such means, then he would be able to give effect to all the teachings of the priest, all the charms would have their proper effect. But were he unable to so shatter the stone or kill the person, then the charms would never be efficient, but they would turn against him and do him serious harm. In some cases, when the tutor was an old person, near his latter end, he would cause his pupil to test his newly acquired powers on him—on the priest tutor. If the latter was slain by these spells of magic, then the pupil's powers were tested and proved. Thus the pupil would be a proved wizard and adept, able at any time, should he so desire, to implant a *mauri* in a forest, or by a stream, or at the *pou reinga* of an eel-weir.

" It would not be well for a pupil to keep his acquired knowledge to himself and not test it. He must prove himself—prove that he has acquired the desired powers—by shattering a stone with a magic charm: then all will be well. Such testing, or disclosing, is meant by the term *whakangawha*.

" Now about the *mauri* becoming polluted. (T. R. is still speaking.) I said the birds would be taken home and cooked. This would not be for fear the *mauri* might be polluted were the birds cooked within the forest—not at all. For fowlers would, while taking birds in the forest, cook some as food for themselves. The birds are taken to the village home because the numerous appliances for cooking and preserving them are there.

" I will now speak of the *hau*, and the ceremony of *whangai hau*. That *hau* is not the *hau* (wind) that blows—not at all. I will carefully explain to you. Suppose that you possess a certain article, and you give that article to me, without price. We make no bargain over it. Now, I give that article to a third person, who, after some time has elapsed, decides to make some return for it, and so he makes me a present of some article. Now, that article that he gives to me is the *hau* of the article I first received from you and then gave to him. The goods that I received for that item I must hand over to you. It would not be right for me to keep such goods for myself, whether they be desirable items or otherwise. I must hand them over to you, because they are a *hau* of the article you gave me. Were I to keep such equivalent for myself, then some serious evil would befall me, even death. Such is the *hau*, the *hau* of personal property, or the forest *hau*. Enough on these points.

" I will explain something to you about the forest *hau*. The *mauri* was placed or implanted in the forest by the *tohunga*. It is the *mauri* that causes birds to be abundant in the forest, that they may be slain and taken by man. These birds are the property of, or belong to, the *mauri*, the *tohunga*, and the forest: that is to say, they are an equivalent for that important item, the *mauri*. Hence it is said that offerings should be made to the *hau* of the forest. The *tohunga* (priests, adepts) eat the offering because the *mauri* is theirs: it was they who located it in the forest, who caused it to be. That is why some of the birds cooked at the sacred fire are set apart to be eaten by the priests only, in order that the *hau* of the forest-products, and of the *mauri*, may return again to the forest—that is, to the *mauri*. Enough of these matters.

"You are right about the *ahi tapairu*. That is for first-born females of families of rank only. They alone may eat of the food cooked at that sacred fire. The bulk of the women eat afterwards."

In the above account the expression employed to denote an offering to the *hau* of the forest is *whangai hau*. T. R. here explains that it is the *mauri* that causes birds to abound in a forest. These birds are, as it were, the return made by the *mauri* and the forest to man, who, in the person of the *tohunga*, located the *mauri* that protects the vitality and productiveness of the forest. The offering of birds made to the *hau* of the forest was probably originally an act of placation or conciliation of the gods of the forest—of Tane and others.

The above description of the *hau* and *mauri*, given by Tamati Ranapiri, of the Ngati-Raukawa Tribe, is so good that it may be considered worth while to preserve it in the original. Hence we so give it :-

"Ko te mauri he karakia i karakiatia e te tohunga ki tetehi mea, ki te kohatu, ki te rakau ranei, ki tetehi atu mea ranei i paingia e te tohunga hei piringa, hei maunga, hei nohoanga mo te mauri. Ka whakangawhatia ki tetehi o aua mea, ka waihotia ki te wahi ngaro o te ngaherehere takoto ai.

"Kaore e noa te mauri. Ehara hoki i te mea i tapu katoa te ngahere here pera me te tapu o te wahi i takoto ai te mauri.

"Mo te whakangawha, he whakapakaru. Mehemea ka akona tetehi tangata e tetehi tohunga ki etehi karakia, ara karakia makutu, karakia whakanoho mauri, me era atu karakia Maori, a ka mohio taua tangata. Na, ka mea atu te tohunga ki taua tangata i akona ra 'Tena! Whakangawhatia o karakia,' ara karakiatia te kohatu kia pakaru, te tangata ranei kia mate, te aha ranei. Mehemea ka pakaru te kohatu, ka mate ranei te tangata, kua tino mana nga karakia a taua akonga. Ki te kore e ngawha (pakaru) te kohatu, e mate ranei te tangata, i whakangawhatia ai, kaore e mana ana karakia. Ka hoki ano aua karakia ki te patu i a ia, i te akonga. Mehemea he tino kaumatua te tohunga, e tata ana ki te mate, ka mea tonu mai taua tohunga ki tana akonga kia whakangawhatia ana karakia ki a ia, ara ki te tohunga. Ka mate te tohunga, heoi kua ngawha (pakaru) ana karakia i ako ai, kua mana. Katahi ka pai te noho a taua akonga, a, i etehi wa e hiahia ai ia ki te whakanoho mauri, na kua kaha ia ki te whakanoho, ki te ngaherehere ranei, ki te wai ranei, ki te pou reinga ranei o te pa tuna (rauiri). Kaore rawa e pai kia noho tonu nga karakia a taua akonga i roto i a ia, kaua e whakangawhatia, ara e whakapakarutia ki waho, a ko te whakapakarutanga ki waho koia tena, me whakapakaru ki te kohatu. Kia pakaru rawa te kohatu, katahi ka pai. Koia tena te whakangawha.

"E rua ritenga o te hau o te ngaherehere. 1. Kei te tirohanga o te ngaherehere e nga kai titiro, mehemea kua noho te manu, ki te patua e ratou he manu i taua ra, ko te manu tuatahi e mate i a ratou, ka hoatu tena ma te mauri. Ka whiua noatanga atu ki te ngaherehere, me te ki atu ano—Ma te mauri tena. Te take, he mea kei puhore a muri atu. 2. Kei te wa o te mutunga o te patu i te manu, ka puta ki waho o te ngaherehere, ka timata te tunu i te manu hei huahua. Ka wehea etehi o nga manu i te tuatahi hei whangai i te hau o te ngaherehere, koia te hau ngaherehere. Ka tunua aua manu i wehea ki te ahi tapu. Ma nga tohunga anake e kai nga manu o te ahi tapu. Ka wehea ano etehi manu ma te ahi tapairu, ko ena ma nga wahine anake e kai. Ko te nuinga o nga manu (i wehea) ka tunua ki te ahi purakau. Ko nga manu o te ahi purakau ma te katoa e kai.

"Ehara i te mea kei tamaoatia te mauri, te ngaherehere ranei, i puta ai ki waho o te ngaherehere tunu ai i nga manu, kaore, inahoki e tunu ana ano ratou i te manu hei kai ma ratou i roto ano i te ngaherehere i a ratou e mahi manu ana. Ehara hoki i te mea ki waho tata o te ngaherehere, engari ki te kainga, ki te wahi kei reira nga raweke maha mo te tahunga (tunuunga).

"Na, mo te hau o te ngaherehere. Taua mea te hau, ehara i te mea ko te hau e pupuhi nei. Kaore. Maku e ata whakamarama ki a koe. Na, he taonga tou ka homai e koe moku. Kaore a taua whakaritenga utu mo to taonga. Na, ka hoatu hoki e ahau mo tetehi atu tangata, a ka roa pea te wa, a ka mahara taua tangata kei a ia ra taua taonga kia homai he utu ki a au, a ka homai e ia. Na, ko taua taonga i homai nei ki a au, ko te hau tena o te taonga i homai ra ki a au i mua. Ko taua taonga me hoatu e ahau ki a koe. E kore rawa e tika kia kaiponutia e ahau moku; ahakoa taonga pai rawa, taonga kino ranei, me tae rawa taua taonga i a au ki a koe. Notemea he hau no te taonga tena taonga na. Ki te mea ka kaiponutia e ahau taua taonga moku, ka mate ahau. Koina taua mea te hau, hau taonga, hau ngaherehere. Kati ena.

"Whangainga o te hau ngaherehere. Ka whakamarama ahau ki a koe mo te hau ngaherehere. Ko te mauri, na te tohunga i hoatu (whakanoho) ki te ngaherehere. Na te mauri te manu i whakahua ki te ngaherehere, ka tikina atu e te tangata, ka patua, ka riro mai i te tangata. Ko enei manu he taonga no te mauri raua ko te tohunga, me te ngaherehere, ara he utu mai no te taonga o te ngaherehere, ara o te mauri. Koia i kiia ai kia whangaia te hau o te ngaherehere. Ma nga tohunga e kai, na ratou hoki te mauri. Koia i wehea ai etehi o nga manu i tunua ai ki te ahi tapu ma nga tohunga anake e kai, koia tera, kia hoki te hau o te taonga o te ngaherehere me te mauri ki te ngaherehere ano, ara ki te mauri. Kati ena.

"He pena ano te ahi tapairu. E tika ana tau, ma nga wahine matamua e kai tuatahi, hei reira ka kai ai te katoa o te wahine."

We have seen that the right wing of a *kaka* is sometimes used as a *mauri*. Another item so used is the *rau huka*, a term applied to strips of the leaf of *Cordyline australis*, the common cabbage-tree, when prepared for making bird-snares.

Bear in mind that if the *hau* of a person be taken, as by the art of black magic, then that person will surely die. His physical body cannot exist without the *hau*. Now, if you apply this principle to the forest, to land. to the village homes, you will see why the *hau* of those places has to be carefully cherished and protected.

When hunters and trappers enter the forest to ply their ancient arts, they may not carry any cooked food with them, or the *mauri* of the forest would become *tamaoatia*, or polluted, and so lose its powers and virtue. The trappers may, however, carry uncooked food, because it has not the above disastrous effects. As a rule some raw fern-root was carried. When desirous of eating, the fowlers would camp for a while, kindle a fire, roast some fern-root and a few birds, and make a meal off these. Should such food be not consumed by the person or persons, they may not carry away the balance of the cooked food to be eaten at another time: it must be left where cooked. In like manner, it would be unwise to eat as they walked, or even in a standing position. It is much safer to sit down, and to remain in that position until satisfied. There is no kind of sense in risking the sanctity of your *mauri* and the productiveness of your forest lands.

In a former paper we told how a wizard could blast the fertility of lands by means of a magic spell known as *papaharo* or *te tipi a Houmea*. When such a warlock essayed to drive birds out of a forest, to cause them to migrate therefrom, he would obtain a bird and pull one feather from it. Holding this in his hand, he would repeat over it,

Hutia atu te huruhuru o te manu
Rere tonu atu te huruhuru
Kore tonu atu te manu.

He then would blow the feather off his hand.

In Kereru te Pukenui's evidence in Ruatoki Block we note the following: "There is a sacred place at Whangai-manuhiri. It is known as a *hau*, or *mauri*. It is a hollow place at the foot of a *rata*-tree. In former times, when people went hunting, a bird would be caught and placed in that hole, and certain charms would be repeated over it. This removed the *tapu* from all the creatures of the forest, birds and rats. That bird was so deposited, and the charms recited, lest evil befall the land. This practice ceased when Christianity was accepted."

The evil here alluded to was sterility, non-productiveness, which would ensue were not the proper rites performed.

A tree at Parahaki, named Tahau-ariki, was a *mauri*. Hunters would make offerings to that tree and repeat certain charms.

Tutakangahau, our most learned man among Tuhoe since old Rakuraku passed away, and who died himself in November, 1907, said, "The *mauri* of a *tutu* (any tree on which birds are trapped by the *mutu* method is so termed) was usually a stone, which, after the necessary rite had been performed over it, would be concealed under or among the roots of the tree." He told me of one such *tutu* and *mauri* situated near his home at Maungapohatu. This *mauri* has been located at the base of that tree for over ten generations. It is just above Torea-a-tai. When the stock-track to Turanga was being made, the overseer, an Irishman, was going to fell this tree, it being on the line of road. Old Tutaka went to look for his *mauri*, and tried to explain to the overseer the meaning and uses of the *mauri*; but the subtle metaphysics of the Maori were too much for the Milesian mind to grasp. He was hopelessly befogged.

"The *mauri*," says Tutaka, "was also used to represent and guard fish." The same talismanic object seems to have often been employed to act for, or represent, fish, birds, and land, and even persons. "The first-fruits of fish were treated in the same manner as those of birds. The first fish was placed away, as was the first bird, as a *taitai*. The fire at which the rite is performed is the *ahi taitai*. The fish or bird is suspended while the rite is being performed, and afterwards taken down and buried as an *ika purapura*. It acts as a *mauri* for birds and fish. *Ka rumakina aua mea hai mauri mo te manu, mo te ika, mo te tangata, mo te whenua* (Those things are buried as a *mauri* for birds, for fish, for persons, and for land)."

Here we see that the one talisman may act for birds, fish, persons, and land. It protects the *hau* of all. The first-fruits rite is still performed in a modified form among Tuhoe—that is, at the *pure* ceremony, when the *tapu* is lifted from crops and other food-supplies.

But a separate *mauri* seems to have been used for sea-fish by the coastal tribes. Each tribe would have its own marine *mauri*—possibly more than one. The first fish of the season would be deposited thereat, and appropriate charms recited. The sea *mauri* of the Whanau-a-Apanui Tribe is a *rata*-tree near the mouth of the Motu River.

THE TUAPA.

Before setting forth to open the season by slaying the offspring of Tane, we will discourse awhile upon the *tuapa* and the *whare mata*.

The *tuapa* may be termed a luck-bringer. It has nothing to do with the *mauri*, nor is it an *uruuru whenua*. Its function is to ward off ill luck from hunters, fowlers, and fishermen. It is a luck-post, but does not, perhaps, possess any inherent or innate power to ward off ill success from hunters. It seems rather to be erected as a mild kind of shrine, a common place where all members of the village community attend to perform a simple rite ere setting forth on a trapping or fishing trip. It appears to be this rite that brings good luck—that is to say, that wards off ill luck—and not any virtue implanted in the *tuapa* post itself. This post, therefore, is not *tapu* as is a *mauri*. Women may approach and perform the simple rite at the former, but they would not be allowed to go near a *mauri*. The word *tuapa* seems to bear the same meaning as *pa*—viz., to obstruct, block up—as in *Ka tuapatia te huarahi, ara ka paia.*

The *tuapa* was simply a piece of some durable timber, as heart of *totara*, dressed with an adze into the form of a thick slab. It was set in the ground as is a post, and stood four or five feet above ground. It was painted with red ochre. Though it could not be styled a *tapu* object, yet it possessed a certain amount of *mana* (influence, power, prestige) because of the rite performed at it. If such post should be destroyed by a raiding enemy, no harm would result; another such would be erected. One of these *tuapa* formerly stood near my camp at Heipipi, Rua-tahuna, but has long disappeared. Paitini says that he last saw it about the year 1870, when the Government troops were searching for Te Kooti. The following account of the *tuapa* was given by old Paitini Wi Tapeka :—

"Ka hui nga tangata nona te whenua. Katahi ka ki tona kai whakahaere tohunga—'Me whakaara he tuapa mo nga tumanako, mo nga tuhira a te tangata, kia kore ai e kaha ki te whakapuhore i te hunga e haere ana ki te mahi.' Ka whakaaetia e te iwi katoa. Ki te mea ka mahi, mahi ika ranei, mahi manu ranei, ka tae noa atu te wahine ki te tuapa, haunga hoki te tane, e tae noa atu. Ahakoa rua whakatipuranga o te tangata, toru ranei, wha ranei, koira tonu te tuapa, kaore e whakaara tuarua ki muri. Kia haere te tangata ki te patu manu, ki te rama ika ranei, ka tangohia e ia he rau rakau, he maramara ranei no te rama, ka whakapa ki ona mea mahi, kupenga, puwai, me te rama tera. Mo te tane, ki te mahi manu ki te tao, ka whakapa ki te tao, ki te kete rau huka ranei, a katahi ka whiua taua rau rakau ki te tuapa takoto ai. Ko te kupu takutaku a nga tangata makamaka pera ki te tuapa :—

"Nga puhore nei
Nga tumanako nei
Nga tuhira nei
Ki konei koutou putu ai
Arai puhore
Whakawhiwhi ki te tama a roa.

"Ko te tuapa, ehara i te mea huna, kai te taha tonu o te kainga e tu ana te pena. Ehara hoki i te mea tino tapu, ko tona tapu kia mana tonu nga mahi. Koina tona tapu."

(The owners of the land assemble. The priestly director says, "Let us set up a *tuapa* against the envious desires of the indolent, that such may not bring ill luck to game-hunters." And all the people consent. When about to set forth on fowling or fishing trips, women may go to the *tuapa*, not to speak of men—of course they may do so. That *tuapa* may be used for two, three, or four generations. The same one will be used, no second one will be erected. When a person goes to the forest to kill birds, or goes fishing, he takes a branchlet (or a fragment of his torch if going fishing) and touches with it his implements- his net and fish-basket if going fishing, or, if it be a man going fowling, he touches with the branchlet his bird-spear, or the basket in which he carries his snares. Then he throws that branchlet (or piece of torch) down at the base of the *tuapa* post. When people so cast such items they recite the following: "Ill luck and indolent desires, lie ye here heaped up. Ward off ill success. Cause man to acquire." A tuapa is not concealed; such things stand near a village. Nor is it a very *tapu* affair. It has just sufficient *tapu* to render the ceremony efficacious: such is its *tapu*.)

We see that, if a man is going birding, he takes a green twig and touches his implements with it, then throws it down by the post, and recites a charm to ward off bad luck in his venture, and also any evil results that might spring from the envious desires of those too indolent to go trapping, &c., but who would like to acquire some of the products of the industry of others. In taking the *kokopu* fish by torchlight, which was usually done by women, a fragment of the torch was used, and deposited at the post.

Some of the expressions used in connection with the above are highly curious. *Tumanako* means "to desire some absent object." *Tuhira* is more rarely met with, and seems to bear almost the same meaning as *toitoiokewa*. It is applied to a person who refrains from joining a hunting or fishing party, but who lets his thoughts dwell upon the game they will bring in, the toothsome dishes that will follow, and so on. He partakes, in anticipation, of the fruit of the toil of others, while yet such fruits, birds, fish, &c., are at large and may escape. If you ask a Native the meaning of the term *tuhira*, he will at once reply "indolence." But it means much more, and does not apply to ordinary laziness. It would not be applied to a person because he was lazy in procuring firewood, for that wood possesses no powers of locomotion, and hence cannot escape or evade pursuit. "*Ou mahi a te mangere he tuhira*," says the Maori. The result of indolence is *tuhira*. An indulgence in *tuhira*, *tumanako*, or *toitoiokewa* is believed to bring bad luck to a hunting-party. To talk about the game you are going to catch is a *toitoiokewa*, and will bring bad luck; it is a *puhore*, a token of non-success. But if you talk about firewood you are going to get, that is neither a *toitoiokewa* nor yet a *puhore*. That wood cannot run, or fly, or swim away. At one time old Paitini was going pig-hunting, as a large boar had been seen at Ma-te-ra. I said, "Now you will get some fine tusks from which to fashion *autui* (cloak-pins)." He replied, "*E tama! Kaua e toitoiokewa, koi patu turi noa iho matau*" (Young man, do not *toitoiokewa*, lest we weary our knees to no purpose).

The word *mahoro* has a somewhat similar meaning to the above. It seems to mean that the home-stayers are thinking of the game or fish that they expect to be brought in, and desiring such, but they do not express their desires in spoken language. *Mahira*, again, seems to imply a churlish selfishness. If I handed over some game to others to cook for me, and watched them closely to see that they did not give any away, then the term *mahira* would apply to my action.

There are innumerable *puhore*—signs or actions that bring bad luck to hunters or fishers. Their name is truly legion.

I remember the late Judge Butler telling me about a trip he took with some Native pig-hunters. Before starting he put in his pocket small packages of salt and pepper, intending to use those condiments when they killed a pig and cooked the liver to serve as a midday meal. His companions strongly disapproved of his action, and said, "*Kaore ano kia mate mai he poaka, kua kainga e koe*" (You are eating the pig before we have killed it). And that is just the Maori idea.

The green sprig of the fowler was applied to the implements of his craft in order to remove certain evil influences. The touch, together with the charm, averted the evil chance. A Maori would term this act a *ripa*, or *arai*. Some of our readers doubtless remember the character in George Borrow's "Lavengro" who "touched" in order to remove the evil chance. He was probably a person of an imaginative and nervous temperament. A learned and cultured person was he, but he ofttimes felt compelled to touch certain objects, or perform some other erratic act, in order to avert misfortune. Peradventure he deemed his *hau* to be in danger of pollution. We have known one or two educated, intelligent Europeans who practised this strange habit—a habit, or superstition, that is a survival of primitive times. We knew one such who, when walking abroad, would sometimes turn back and touch a certain object, or pass round the further side of a tree or post. The feeling that prompted him to do these things was a strong one, and, should he force himself to disregard it, then a sense of impending misfortune weighed heavily upon him. But this is surely digression.

THE WHARE MATA.

Of this institution old Tutaka said, "The *whare mata* was a house built for the purpose of manufacturing therein all implements used in hunting, fowling, and fishing, and for the storage thereof. Thus all nets, snares, traps, &c., were made in that building. It was a very *tapu* building, and no cooked food was allowed to be taken into it; hence no one might eat therein. Nor was any woman allowed to enter it. In the *whare mata* are stored all the implements mentioned, when they were not in use, as also the baskets used for holding and carrying seed *kumara* (sweet potatoes). It would be wrong to allow such baskets to be taken to cooking-sheds (*Ko aua kete, kaore e tika kia heria ki muri*). Men worked only at making hunting and fishing paraphernalia in this building. They might not eat or live therein. The *rau huka* (leaves of *Cordyline australis*) were prepared and formed into snares in the *whare mata*."

Tamarau Waiari said, "Ko nga rau ti he mea haehae ki te whare mata. Ko taua whare, he whare whapiko rau huka. Kaore e tae te wahine ki reira, kaore e tae te kai ki reira. Kia maoa rawa te umu rau huka, katahi ka noa taua whare me nga tangata, katahi ka haere nga tangata ki te moe i o ratau wahine. He whare motuhake tena mo taua mahi, kaore he mahi ke. Katahi ka haere, ka heria aua rau huka, ka taia ki runga ki te kahika, ka whakairia. Na, ka mau nga manu tuatahi, katahi ka homai ki te hapi (umu) rau huka, katahi ano ka kainga e nga tohunga, katahi ka noa aua tangata. Ko nga rau ti he mea karakia, he rau huka te ingoa o te karakia."

(The cabbage-tree leaves are split and prepared in the *whare mata*. That building is a place where snares are made. Women are not allowed in it, nor yet is food. When the *rau huka* rite has been performed, then that house and the persons engaged therein are free from *tapu*, and they may then return to their homes. The *whare mata* is a house specially devoted to these tasks; no other work is performed in it. Then the snares are taken to the forest and arranged on the white-pine trees. Now, the first birds taken are cooked in the *rau huka* oven and eaten by the priests. Then the persons engaged in these tasks are freed from *tapu*. A charm is repeated over the snares made from *Cordyline* leaves. That charm is styled *rau huka*.)

Tamati Ranapiri, of Ngati-Raukawa, stated, in answer to a query, "Yes, a special house was set apart wherein were manufactured snares, traps, nets, and such things. The reason of this was that it was most undesirable that women should be allowed to approach the hunting and fishing paraphernalia, or the materials from which they were fashioned, or the makers thereof, so long as the *tapu* was on the *whare mata* that is to say, on its inmates and their work. The presence of a woman would pollute, or nullify the efficacy of snares or nets. *He wehi no nga tane kei pikitia nga harakeke e nga wahine, ara nga harakeke e mahia ana mo nga kupenga me nga mahanga.*"

SNARES, ETC.

Flax was not used by the Tuhoe folk wherefrom to fashion snares. For this purpose they invariably utilised the strong fibrous leaves of the *ti* (*Cordyline australis*), the same being much more durable than flax when exposed to the weather. Moreover, no good variety of flax is found in Tuhoe-land, but merely inferior kinds, the leaves of which contain a very poor fibre. The leaves of the *ti*, or cabbage-tree, are split into strips. These strips are dried and then stained by immersing them in a black (? ferruginous) mud, or by hanging them in the smoke of a fire of resinous wood (*mapara*). This process is for the purpose of giving the snares, and the cord to which they are attached (*takeke* or *kaha*), an old appearance. If they were left in their natural colour they would look new, and birds would be shy of them. Each of the above strips is formed into a loop snare, a running noose, at one end. The other end, the free end, serves to suspend the snare from the main cord, which is strung from branch to branch of the tree. Hundreds of such snares would be set among the branches of a large tree much frequented by birds, such as a *kahikatea* of great fruiting-powers. The act of forming the loop snare is termed *whapiko*, of which *tapiko, kopiko*, and *rapiko* are variant forms. The first of these words is probably an abbreviation of *whakapiko*, but it may be *wha* (a leaf) and *piko* (curved, bent). The act of setting snares all over a tree-top is termed *ta* and *tahei*.

The first act of the fowler, when setting the first snares of the season is to stretch the cord from which the snares are suspended from branch to branch of the tree. These cords must be strung well out towards the ends of the branches, because that is where the fruit and flowers that attract the birds are situated. This means that the task is one of great danger, and many fowlers have been killed by falling from the branches of great forest-trees. Try to imagine the task of setting snares on the outer branchlets of a lofty white-pine tree. We yearn not for that task, but prefer a shot-gun or, better still, a poulterer's shop.

The cords having been strung and secured to branchlets, the snares are then suspended from them in such a manner that birds will be likely to thrust their heads into the nooses as they move about in feeding. When fruit is plentiful on the tree the snares are set but a short distance apart. When the fowler revisits his snares the following morning he takes the snared birds from the taut nooses and resets the snares. If a good take, the dead birds will be numerous, hanging in rows on the tree—that is to say, in days gone by, when birds were many in the land. The act of taking the snared birds from the nooses is described by the word *wherawhera.* One asks, "*Kai hea ra a mea ?*" (Where is So-and-so ?) Another replies, "*Kai te wherawhera*" (He is opening out—"nooses" understood). The special term to denote this act—*ui,* to relax a noose—does not seem to be employed in this district.

Women often engaged in the task of setting snares, and also in *wherawhera,* or collecting the snared game. The trees easiest to climb were often allotted to women. A tree named Kake-wahine, at Maunga-pohatu, was so called because women used to work it in the bird-snaring season. Fowlers carried a basket made of flax or *ti* leaves, and termed a *kete wherawhera,* wherein to deposit and carry the birds secured by them. A very early start was made by fowlers in the morning, so as to be on the snaring-trees before the birds began to frequent them. They would leave home before daylight, and, indeed, often awaited dawn perched on a tree. Each person had certain trees allotted to him, on which he had the right to take birds, and which he visited every day during the season. Thus he had a set route to traverse every day. It would never do for a person to attempt to take birds on any trees but those which belonged to him. Even the different members of one family often had different trees allotted to them, though they often worked them together. If a man had more trees than he could attend to, his relatives, sometimes females, would assist him.

A Native would not use the word *wewete,* or its reduplicate form *wetewete,* in speaking of taking snared birds from the nooses, because he deems it a *puhore* (bad luck) so to do. He uses the term *wherawhera* (reduplicate form of *whera,* to spread out, to open), as, "*Haere ki te wherawhera i to rakau.*" Again, he would not say that he was going to *titiro* (look at) his pigeon-troughs (*waka*), for that also would bring ill luck—he would find no birds caught, or but very few. He uses the term *matai* (to examine) in this case—"*Haere ki te matai i ou waka.*" It would appear as though the Native refrained from using the more common expression lest the birds hear, understand, and so avoid the snares. It bears some resemblance to *toitoiokewa.*

Of the *ti* leaves Paitini says, "*E takoto tinana ana te ti, e kiia ana he ti, no te haehaetanga o te ringa kia ririki, ka huaina te ingoa he rau huka. Ko etahi o aua rau huka ka whiua ki te ahi taitai kia waimarie ai e ka kawea atu ki te tahei, te waimarie he mate nui mai no te kai, ara no te manu.*" (Before a *ti* leaf is prepared for snares it is simply termed *ti,* but when it has been split by hand into strips it is styled *rau huka.* Some of these *rau huka* are cast into the *taitai* fire in order that the snares may be efficacious in taking birds when they are set. By "efficacious" is meant the slaying of much food—that is, of many birds.)

A snare is termed *mahanga,* but when a series of snares is set on a tree they are alluded to as *tahei.* The actual noose is called *tari.* The latter word seems to be used as a verb by Tuhoe—'to catch with a noose"—only when the noose is handled by a person when used as in noosing *ruru, weka,* and *porete,* also in so catching a horse.

There were many different *karakia,* or charms, used by fowlers when bird-catching. Such charms used when fishing, snaring birds, or trapping rats were known by the generic term of *kaha.* One such was known as the *tumutumu* charm. Another, termed *tuota,* was a very *tapu* charm. If a man used this charm it would be necessary for him, on his return from the forest, to make an offering to the gods. (*He tapu tenei kaha a Tuota. Mehemea ka tuota, ka hoki mai te tangata i te ngaherehere, me whangai, ara me whangai i te atua.*) This charm was a very efficacious one for taking birds, rats, and fish. Another *kaha* charm was called *motumotu.* This was not a *tapu* charm, and was used to insure fowlers a good bag.

FIRST-FRUITS RITES.

The Taumaha, Ahi taitai, Ahi matini, *&c.* *Astrolatry.*

The rite of first-fruits was one very generally performed in Maoriland in former times. In this district it seems to have been known as *amoamohanga.* This name may have originated in the fact of each little village or family group bearing its own first-fruits to the place where the rite was performed.

The following is the only item pointing to anything like a system of star-worship that I have obtained from the Tuhoe Tribe. It was given by Tutakangahau. He says,—

" In regard to invocations to the stars, there were such invocations in former times, and here is one :—

" Tuputuputu atua
Ka eke mai i te rangi e roa e
Whangainga iho ki te mata o te tau
E roa e.
Atutahi atua
Ka eke mai i te rangi e roa e
Whangainga iho ki te mata o te tau
E roa e.
Takurua atua
Ka eke mai i te rangi e roa e
Whangainga iho ki te mata o te tau
E roa e.
Whanui atua
Ka eke mai i te rangi e roa e
Whangainga iho ki te mata o te tau
E roa e.
&c., &c.

" There is much more of this invocation, because all the (principal) stars were included. When the season for collecting food products and for cultivation of foods (planting crops) begins, then the priest gathers some young leaves of plants, &c., and offers these to the stars, and recites the above invocation to the stars. All stars that cause fertility and abundance of food products are thus mentioned. The leaves are taken to the sacred place and offered to those gods. This invocation, with its attendant rite, is to cause all food products to flourish, and to ward off any disaster from such products. The *mata o te tau* means the young growth of the new year."

The above is more than a charm or incantation—it is an invocation: it invokes the help of the stars, it calls upon them to cause the season's crops of all kinds to be bountiful. It is the nearest approach to a prayer of anything that I have collected from Tuhoean sources. It will be observed that samples of the new young growth of the season are offered to the stars named. Certain stars are supposed to possess an influence in regard to fruitfulness and fecundity in nature. One of old Tutaka's remarks is worthy of preservation in the original: " *Ko nga otaota o te tau hou ka kohia e te tohunga e ka timata nga mahi o te tau, a ka whangaia aua mea ki nga whetu. Ko nga whetu heri kai mai ka whakahuatia katoatia. Ka heria nga otaota* *ki te tuahu, a ka whangaia ki aua atua. Ko te tikanga o tenei mahi, kia pai te tupu o nga kai, a koi pa mai he mate ki aua kai.*"

Tuputuputu, mentioned in the above invocation, is the name of one of the Magellan Clouds. Atutahi is Canopus, Takurua is Sirius, and Whanui is Vega.

First-fruits of Birds.

The first-fruits of the bird season—*i.e.*, the first birds taken—are offered to the gods—to Maru, Tunui-a-te-ika, and others—as also are the first fish taken. First-fruits are sometimes termed *whakaaweawe*, a name that applies to anything, animate or otherwise, that may be offered to the gods.

The rite of first-fruits is performed at a sacred fire known as the *ahi taitai* (*taitai* fire), at which many different rites are performed, but not those pertaining to war or death. The word *taitai* is, in one sense; a sacerdotal term, and its meaning is by no means easy to define. Williams's Dictionary says, " *Taitai*, to remove *tapu* from a new canoe." But Tuhoe were not a seafaring people, and do not seem to know the term in that connection. As a verb, *taitai* means to perform the *taitai* rite at a sacred fire (known as the *ahi taitai*, or *taitai* fire), to repeat the charm termed *taitai* which renders that fire *tapu*, or sacred, by locating therein the gods —*i.e.*, the power of the gods, which is the spiritual power that renders the rite, whatever it may be, effective. The word *taitai* is also used in connection with the providing of food—" *Kai te taitai kai a mea ma koutou.*"* This may be said to a company of travellers. Some one has heard that they are coming to or passing his place, and turns to provide a meal for them. If the party have no time or inclination to stay and partake of such food, one at least of the party must stay and eat a portion, however small, thereof, otherwise the act of passing on would be a disregarding of Tahu (the emblematical name, or tutelary deity, or personification, of food).

Rites are performed at the *ahi taitai* that they may be effective. When, on the opening of the bird season, the snares are made in the *whare mata*, some of the *rau huka* are cast into the *taitai* fire. At the same time certain charms are repeated to insure a good catch of birds, to bring many birds into the snares. We note that Williams gives *taitaia* as meaning " unlucky in fishing," &c. The *ahi taitai* is sometimes termed the *hau* or *mauri* of a *kainga* (village), presumably because the rite by which such a *mauri* is installed, or sanctified, is performed at it, and also other rites conducive to the welfare of the place and people.

Tamarau Waiari said, " About the *ahi taitai:* This fire (*i.e.*, rite) is for the purpose of bringing many birds and fish to the tribal lands. First-fruits are offered at this fire. When we are going to perform this rite over certain lands, we kill a bird—a *kaka*, or *koko*, or *miromiro*, or *tiwaiwaka*—any bird—as an offering. The charm repeated is the following :—

" E Papa e takoto nei
E Rangi e tu nei
Homai te toto kai tangata
Kia rurukutia, kia herea
Kia mau te mauri
Te mauri o wai ?
Te mauri o Tane
Tane tuturi, Tane pepeke
Whakamutua ki a Tu-matauenga
Whakamutua ki a Paia
Nana i toko te rangi
Na Tu-matauenga i here te kai.

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* See Addenda.

Such are the performances at the *ahi taitai.* At this fire were performed many sacred ceremonies pertaining to the home, but not those pertaining to war. The first bird taken served as an offering to the gods. It was placed on a tree near the *taitai* fire. Then the officiating priest recited the charm by which birds were lured to the tribal lands. Then persons might commence bird-snaring."

A *taitai* charm is given in Taylor's "Te Ika a Maui," the translation of which should be looked at askance.

Any place where a *taitai* fire had been kindled remained sacred. So *tapu* was such a spot that any person trespassing thereon was believed to be doomed to death unless he procured the services of a priest, who, by means of a certain exorcising rite, could save his life. The priest would charge a fee, payable in goods, for his services.

Paitini states, "The first few birds taken when the season is opened are cooked at the *taitai* fire and eaten by the officiating priest, and this act of his lifts the *tapu* from the proceedings, and the rest of the people, including women, may partake of food, take part in the ritual feast. The *taumaha* or thanksgiving charm is recited at the above rite, when the first birds are cooked. After the *tapu* is abolished, women were sometimes served first with food. The *rau huka* fire I spoke of before was a *taitai* fire."

The women spoken of above as being first served would be women of rank only.

Tutakangahau explains that *whakau* is a charm repeated over food that is excessively *tapu,* in order to render it innocuous--that is, lest its *tapu* be harmful to those who partake of such food. The *whakau* rite lifts the *tapu* from persons and food. The *taumaha* is another charm repeated over food that is *tapu* in order that it may be safely partaken of by the people —it removes the *tapu.* There are many different *taumaha* charms, each having its special use.

Taumaha in Nukuoro seems to mean a feast or ritual feast. The European grace repeated over food about to be partaken of is alluded to by Natives as a *taumaha.*

Tutaka says, "There is a *taumaha* repeated over first-fruits of birds, fish, &c.—the first of the season brought in. The first bird taken is carried to the village home, where the priest manipulates it. The ceremony is performed at the *ahi taitai,* a sacred fire kindled by the priest, or by a person termed a *takuahi,* whose sole duty is to kindle these sacred ceremonial fires. Such fires are always *ahi pahikahika*—that is, fires kindled by the friction process, generated by hand. They are never kindled by means of brands from another fire.

"The first thing done by the priest after the fire is kindled is to repeat over it the charm (or invocation) called the *taitai* :—

"*Ka ka te ahi taitai. Katahi ka taitai. Ka tu te tohunga, me te rakau i tona ringa.* (The *taitai* fire burns. Then the *taitai* rite is performed. The priest stands with a wand in his hand) :—

"Taitai, taitai, taitai
Te kau nunui, te kau roroa
Te rupe tu, te rupe pae
Pekepeke hauaitu te manu waero rua
Te hau e tu nei, taitai
Mai ra a tu, mai ra a pae
Pekepeke hauaitu te hau e tu nei.

Ko te karakia taitai tenei. Koinei nga kupu i tapu ai te ahi. Ko nga atua katoa ka whakanohoia ki taua ahi, hai patu, aha ranei. (This is the *taitai* invocation. These are the words by which the fire is rendered sacred. All the gods are located in that fire, to slay, or what not.)

"*Manu-waero-rua* means 'wind, a strong wind.' That is Tawhirimatea.

"The first-fruits of the birds of the forest are brought in. The priest takes the first bird. The feathers thereof, and piece of some edible herb, are roasted at the fire. They are taken from the fire, and the priest repeats over them the *taumaha* :—

"Taumaha kai te motumotu
Kai te ngarehu, kai te kapekape
I aua kia mate, i aua kia irohia
Ka ma Tupakaka, ka ma Rakaihika
Ka ma te kapiti
Te kapiti ki tamaoa
Tena taumaha, taumaha ka eke
Ka mama nga pukenga
Ka mama nga wananga
Ka mama hoki ahau
Tenei tauira.

"Tupakaka and Rakaihika were ancestors of very remote times who originated the *taumaha*. The body of that first bird is suspended over the fire. The semblance (*ahua*) of that first bird—*i.e.*, the feathers—the priest touches to his mouth. No unauthorised person may approach this sacred fire; it would spell death to do so. The body of the first bird is placed upon a stage. A portion of it may be eaten by the priest if he is of sufficiently high standing; if not, it is left for the trees to eat it—that is, it is thrust into or impaled on (*kohika*) a tree, and left for Tane to eat. That bird left on the stage (*whata*), or on a tree, is afterwards taken down, and to it is added the *hau* of the person of highest rank (*ariki*) and the *hau* of the land. After a while it is buried as an *ika purapura* (seed-fish), which is the *hau* of the people and land. Its duty is to guard the land, the people, and the birds—to preserve them from harm. It acts as a *manea*, and preserves all from evil influences or machinations. It is the salvation of man. I have seen this rite performed," says Tutaka, "and have performed it myself (*kua taitai ano au*).

"And now other birds are brought and are cooked for the *ati a toa* and the forest craftsmen, the fowlers. After that the *tukupara* takes place—that is, a large quantity of birds is cooked and eaten by the bulk of the people. When the contents of the *tukupara* oven have been eaten, then the ceremony is over. The *tapu* is now lifted. The forest, the birds, all the people are now *noa*, or free from *tapu*. The season is open. People now set to work, some going bird-snaring, and some set to work at potting birds.

"Now, should travellers or visitors arrive at a place where the *taitai* rite is being or is about to be performed, which place is therefore still in a state of *tapu*. those visitors will not partake of food at that place—not in any case.

"The *taumaha* repeated over the first-fruits of fish is the same as that used for birds, save that the name of Tangaroa is inserted in the place of those referring to Tane and birds.

"In case of the products of forest or stream, as birds, fruits, and fish, becoming scarce or afflicted in any way, as by disease, the adept who has charge of the *rahui* will go and get the *kapu*, or object that represents the *rahui*, and take it to the *ahi taitai*, where certain charms are repeated over it in order to cause it to wake up—for it has been asleep—and to restore the healthy productiveness of the forest, &c. It is not the power of the *rahui* alone that is invoked in order to bring about the desired change, but also that of the *mauri* of the land, of persons, of the waters in fact, of all things. Then the *taitai* rite is performed, that food products may flourish— birds, fish, fruits, and other things.

"The *ahi taitai* is a sacred fire, and is exceedingly dangerous to man, for man can be destroyed by means of rites performed thereat. It is only for *tapu* purposes that it can be used. Other fires are kindled whereat to cook food for the *tapu*-lifting ceremony. The *ahi taitai* was for the gods only. The different fires (and ovens) kindled for the freeing from-*tapu* rite were,—

"(1.) The *ahi tuakaha* for cooking food for the priest only.
"(2.) The *ahi marae*—for the *ati a tou*.
"(3.) The *ahi ruahine*—for priestesses and first born females of high-caste families.
"(4.) The *ahi tukupara* for cooking food for the bulk of the people.

"Understand that no one could cook or eat a bird until the above rite had been performed in order to placate Tane and other gods. Travellers and others would endeavour to avoid any village at such a time if the *tapu* was not yet dispelled."

The Ahi Matini.

"The *ahi matini*," continues Tutaka, "was also an *ahi taitai* another form of it. The *matini* fire was a rite performed by fowlers and hunters at their temporary camps in the forest, while engaged in trapping, &c. The *ahi matini* is an ancient fire (*i.e.*, an ancient rite), practised from remote times. It was a sacred fire at which were roasted *tapu* birds. The *taumaha* would be repeated over the bird, and it would be eaten by the priest, in order to take the *tapu* from the place. When the (first) birds were killed they were taken to the camp, and one of them was roasted at the fire. The priest, I say, ate that bird and took the *tapu* off the place— off the forest, the birds, and the work. This had to be done because of the slaying of the birds (a placation of the forest-gods). After this another bird (or birds) was cooked at a separate fire, and was eaten by the workmen, the fowlers. This rite was performed at the forest camp."

Here ends Tutaka's account of the *ahi taitai* and its rites. He was a man who possessed a vast amount of very curious knowledge. His mind was a storehouse of primitive lore. He knew the old Native names of every tree, shrub, plant, or fern in the forests of Tuhoeland. His fund of quaint folk-lore was immense. Above all, he was thoroughly conversant with the modes of thought of the ancient Maori. He could explain the strange metaphorical expressions of the men of yore, and the still stranger belief in the life-principle of inanimate objects. For his was the knowledge of the strange workings of the primordial mind—the mind that sees more than we wot of—and a knowledge that shall not be acquired by the *pakeha*, strive he never so hard.

On the occasion of my last interview with the old man he gave me some curious and archaic invocations of the men of yore, as to how the priests made sacred the ritual fires and located therein the dread presence and powers of the gods. After which he said, "*E tama! Ko au anake o Tuhoe e mohio ana ki enei mea. Katahi ano au ka korero i enei mea, kore rawa nei au i korero i mua. Ko koe anake e mohio ana. Ka waiho ko koe hai tohunga mo te iwi.* (O son! I alone among Tuhoe know of these things, and now for the first time I tell them. I have never divulged them before. You alone know them, and you shall remain as a *tohunga* [priest, adept] for the tribe.)

But Tutakangahau, son of Tapui, of the Children of the Mist, has lifted the trail of Maui of old, and has entered the snare of great Hine, the goddess of Hades. And he has taken the bulk of his knowledge with him. Only the fragments, filched by a member of an alien race, are here offered.

About that *matini:* We find not this word in our Maori dictionaries, but the tribes of far Polynesia have preserved it. The Rev. J. B. Stair mentions it in the "Journal of the Polynesian Society," vol. v, p. 47, where he says that *matini* was the name applied to offerings of food made to spirits (*aitu*). Mr. Tregear, who kindly looked up the word for me, says, "In Samoa *matini* is an offering made to induce *aitu* (spirits, gods) to pass over, without calling, the place where such offering is made. In Futuna *matini* means a bundle of coconuts or bananas for use in certain heathen ceremonies. In Mangareva *matini* means 'formerly, in old times.' The Sunda (Java) *matih* means 'efficacious, powerful.'"

The word *ta* (as also *tahei*) we have noted as meaning "to arrange numbers of snares on a tree." This is presumably allied to *ta*, to net, as in making a net. Paitini says, "*He ta mahanga te mahi o te whare mata. Ko aua mahanga ka taia ki te rakau.*" (The work of the *whare mata* is the making of snares. Those snares are arranged on trees.) He goes on to say that the first birds caught are taken home and roasted at the *ahi ka huka*, sometimes termed *ahi huka* and *ahi rau huka*, which is evidently the *taitai* fire. This was done, says Pai, in the *tapu*-lifting ceremony, and when that was concluded the fowlers might return to their wives and families and again enter the meeting-houses and mix with the people; for they might do none of those things while *tapu*.

This same old man also gave me another *taumaha* charm, as recited over first-fruits of birds and fish. He said, "The *taumaha* is a charm repeated over the food products of forest and stream. Here follows the charm said over the first bird taken in the season. That first bird serves to collect all birds of the fruitful forest. (*Ko te taumaha, he karakia mo nga kai o te ngahere, mo nga mea o te wai. Ko te manu tuatahi e ami ana i nga kai o te motu huahua.*)

"Te manu ruru mai,
Ruru mai, nenoke mai,
Ki te pae runga,
Ki te pae raro,
Te manu te ruru pae,
Te noho pae.
Te manu kai te whio.
Kai te taki, kai te kowiri
Kai te ioio nui no nga (? nona).
Te manu kai toroti, kai torota
Kai toro atu rama ki a Tane
Te manu te ruru pae
Te noho pae
Te manu kai te whio
Kai te taki, kai te kowiri
Kai te ioio no nga (?).

"This charm is recited in order to cause all birds in the district to gather to the forest lands of the tribe or family group of which the reciter is a member. The next act is the cooking of the bird. It is stuck on a spit and roasted. It is then eaten by the officiating priest. He may not touch the birds with his hands, hence he has to pull it off the spit with his teeth.

He then eats it as it lies on the ground, gnawing at it as would a dog, and spitting out the bones. The reason of this action is that his hands have already eaten (or touched) the bird while in its raw state. That is over, and it is now the turn of the mouth to eat it. The first-fruits of land and water are now collected together and cooked, and the *taumaha* is repeated over them."

Paitini here gives the same charm as that already inserted in this sketch, save that he inserts these extra lines after the reference to Tupakaka and Rakaihika:—

Tena hoki taumaha ka eke kai o runga
Marie mai ki taumaha
Popoko mai ki taumaha.

This evidently implies an appeal to the above two beings to send the fowlers good luck in their pursuit.

The rite known as *amoamohanga* seems to have been a lifting of the *tapu* from cultivated foods, crops—*i.e.*, *kumara* and *taro*. A small portion of the crop of each family was taken to a central place, where a priest performed the *pure* rite over them. This was the occasion of an important ritual feast. Pio, of Awa, says that it was celebrated in the ninth month of the Maori year—that is, about February and that the names of the different ovens in which food was cooked for the ceremonial feast were *imu tapakaha* (?), *imu kohukohu*, *imu kirihau*, *imu potaka*, *imu waharoa*, as known to the Ngati-Awa Tribe. This word *imu* is a variant form of *umu* (a steam oven).

A peculiar instance of the offering of first-fruits may be found in the "Journal of the Polynesian Society," vol. vi, p. 157.

Instances of the beliefs and practices of first-fruits rites, the *mauri*, *tapu*, ceremonial purification, and many other *cosas de Maori*, may be noted in Judaism and other Eastern cults.

IMPLEMENTS FOR TAKING BIRDS, AND THEIR USES.

We will speak of the trees on which birds are taken by snare or spear; for it is by no means the case that any tree will serve such purpose. In the first place only trees of such species as bear fruit eagerly eaten by birds, such as the *toromiro*, are utilised, and those trees are not found as a rule in large numbers, but scattered about in the bush. The *kahikatea* is the only one of the best species of snaring trees that is found in large numbers—that is to say, that forms a forest itself—and that only in some places, as in low, swampy ground. All forest-trees fruit more plentifully in some years than in others. Many trees seem to so bear abundance of fruit about every third year. Again, all *toromiro* trees do not fruit. Those that do so are termed female trees by the Natives, the others are said to be the males. The latter are, however, much less numerous than the former.

In some cases a certain berry is eaten by some species of birds but not by others. The leaves of some trees are eaten by birds, as the pigeon eats leaves of the *kowhai* and *houhi-ongaonga*. Their flesh is not esteemed when the birds are feeding on these leaves; it is offensive, and in poor condition. The leaves eaten by birds seem to be termed *puruhi*. "*Ka haunga nga kiko o te manu i te puruhi.*" Also, birds are always thin when living on leaves—"*Kaore e momona te kereru i te kai puruhi, he tupuhi. Hai aha!*"

In the case of the *rata* tree, birds flock to it in numbers in order to obtain the honey contained in its blossoms. This nectar is called *wai kaihua*.

"*Ka kai te kaka i te wai kaihua, ka kiia he rarangi tahi.*" When the *kaka* are seen feeding on the *wai kaihua*, it is said to be the *rarangi tahi*. This latter term was applied to the last great rallying or gathering of birds, principally *kaka*, on the hill-growing *rata* when it blossoms. The *rata* trees growing on the ranges bloom later than those situated in the valleys. The *kaka* in former times gathered in great numbers on these mountain *rata* to partake of the *wai kaihua*. They were very fat at this time, and could not be lured by a decoy, or taken either by the *mutu* or *pae* methods. Hence they were taken by spear alone at such a time. *Kereru*, *koko*, and other birds also flocked to these trees, and many species would be seen on a single tree. This general gathering of birds is termed *rarangi tahi*. It is an expression often heard, as, "*I mua, i te wa o te rarangi tahi*" (In former times, in the time of the *rarangi tahi*). For it is now practically no more, so scarce have birds become. This period occurred about January. That was the spearing-time. Prior to that the *kaka* was taken by the *mutu* method. In giving evidence in a Native Land Court, a local Native said. "*Kaore he toromiro o tenei taha o te poraka, he rarangi tahi tenei*" (There are no *toromiro* trees on this side of the block; this is a *rarangi tahi*). He meant that *rata* were the principal bird-trees on this side.

We have four different names applied to trees on which birds are taken, which names refer to the methods employed for taking the birds:—

(1.) *Tutu.*—Any tree on which birds are taken by the *mutu* method is so termed.

(2.) *Taumatua.*—Any tree on which birds are taken by the *tahei* process—*i.e.*, the snares are arranged on the tree-branches, and not on an artificial perch.

(3.) *Kaihua.*—A tree on which birds are speared. An old saying is, "*He toka hapuku ki te moana, he kaihua ki uta*" (A *hapuku* fishing-rock at sea equals a *kaihua* on land). Because both provide an abundance of food.

By the way, did it ever strike you how poetic similes appeal to the Maori mind, how many a pithy saying is in the form of a distich? These poetic comparisons are most numerous, are of a rhetorical character, and marvels of condensation: *e.g.*, *Hohonu kaki, papaku uaua* (Deep throat, shallow muscles)—which explains itself. The triad does not appear to have been so cultivated by the Maori. A triad for the Welshman, a distich for the Maori.

(4.) *Tipapa*, or *rakau tipapa.*—This name seems to be applied to a tree much resorted to by pigeons. We have seen that *tipapa kereru* means "a flock of pigeons." *Tipapa* is apparently a form of *whakapapa*. A *taumatua* is often termed a *rakau tipapa*.

It is a fact that every tree that comes under the above headings—that is, every tree famous as a bird-tree, and on which birds are, or were, taken each season—has its own distinct name. We give a few examples:—

Wahianoa: A *kahikatea* tree, a famous *taumatua*, standing at Heipipi, Rua-tahuna.

Takapari: A *hinau* tree at Te Rua-kuri, on Te Purenga Block. When this tree bore much fruit it was deemed a sign that a plentiful season was at hand. If it produced little fruit, then a lean season followed.

Te Whare o Rakau-tawhia : A *kaihua* tree at Te Hereherenga, Tarapounamu, where Te Karaha, of Ngati Whare, was slain by Tuhoe.

Ranina : A *matai* tree at Manga-kakaho, on which *koko* were taken with snares (*he rakau tahei koko*). This word should be spelt as *raninga*. It is said to be derived from *rara*, which seems curious. When many *koko* were caught in the snares they looked as if they were *rara ana ki te ahi* (suspended before the *ahi matiti*).

Manuruhi : A *kahika* tree, a *kaihua*, situated at Pu kareao. This tree is mentioned in a song composed by one Uhi-tere a lament for her husband : -

He manu maunu au kai te tao
Na Te Kurapa e whakatoto ra
Te kaihua kai Manuruhi ra.

Any place where a named tree stands is always known by such name.

Hei-pipi : A *kahika* tree at Te Wera-iti. *He rakau tahei koko.* Great numbers of *koko* were snared on this tree in former times -so many that they looked like a *hei pipi* or *tahei pipi*—strings of the *pipi* shellfish hung up to dry.

Kaka-nui, O-hira-moko, Kako-wahine, and Pou a Te Wini are all names of such bird-trees, and also place names.

Another distichous saying :--

Ko Kaitara ki uta
Ko Mou-tohora ki waho ki te moana.

Kaitara is the name of a *toromiro* tree at Te Wera-iti, famed as a resort of pigeons, while Whale Island is a famous fishing-ground. The one is a *hapuku* rock, the other a pigeon rock (resort), says Pai.

In days of old, when a man was going a-snaring or hunting he would take his son with him, or a nephew, while they were young lads, so as to point out to them the tribal or subtribal boundaries, landmarks, and all other remarkable places. He would show him all snaring-trees and teach their names, telling to whom they belonged, and so forth. In this wise : "This is a *tutu ;* its name is - ; you will manipulate this tree. This is a *kaihua*, and its name is ; it belongs to" such a family group. "This, again, is a *wai tuhi*, and will be worked by the children of" such a person. "These *waka kereru* belong to the descendants of , who will use them. That stream yonder is named ; it divides our lands from those of ———: you can fish that stream from its junction with the - • - River up to" such a point, "but no further."

Women, when fishing by torchlight at night, often took their children with them, and instructed them in a like manner.

The term *wai tuhi* is applied to such small pools of water as are found in hollow places on trees, logs, and rocks, and which, being resorted to by birds, are covered with many snares, so that the birds, when drinking, thrust their heads through the snare-loops, and are so captured. A pool not so used is not termed a *wai tuhi. Tuhi* is a very curious word of the Native tongue, and it will often puzzle you should you rely merely on its meanings as defined by Maori dictionaries. Te Wai-tuhi is a place-name near Tarapounamu, the name being derived from a *wai tuhi* hard by, a diminutive pool of water lying in a hollow of a *tawa* tree. *Wai tahei* is a name applied to streams, or larger pools on the ground, where pigeons go to drink, and hence are covered with snares—of which more anon.

We have seen that the trees much used as snaring or spearing places by fowlers were often rendered prolific by means of a *mauri*, and their vitality and productiveness protected by very peculiar guardians. When Tuhoe slew Tionga, of Te Arawa, at Puke-kai-kahu, Te Tokai, of the former tribe, cut off Tionga's head and took it to Te Whaiti, where he placed it on a famous birding-tree named Matawera, at Okahu, as a guardian for that tree, which was a *tutu*. Hence the descendants of Tionga are often styled Tiaki Tutu (*tiaki*, to guard). Such descendants, however, do not accept the appellation as a compliment—far from it.

We must now fix up that bird-tree. When it was decided to use a certain tree as a *tutu* for taking birds on, the priestly adept would render that tree *tapu* by means of a certain *karakia* (charm, spell, invocation, incantation). The priest then takes the *hau* of the tree—that is, something to represent the *hau*. He takes the first bird caught on that tree, or simply the *kira* of such bird, and hides it in the forest. That is for the purpose of thwarting the evil designs of enemies. Should any one attempt to destroy the fruitfulness of that tree, to *tamaoa* it, or drive the birds therefrom, he will surely fail, because the *hau* (*mauri*) is concealed. Such a tree has no *hau* (?) until the invocation has been repeated over it by the priest, neither was the tree *tapu* prior to the performance of that rite. (*Ma te tohunga e whakatapu i te rakau. Mo te tangata raweke taua mahi. Ka patu te tangata i taua rakau, kaore e mate, notemea kai te huna te hau. Kaore he hau o te rakau i te wa kaore ano kia karakiatia e te tohunga. Kaore hoki he tapu i taua wa.*)

A person might seek to destroy the utility of the tree by means of finding the *mauri* (which represents the *hau* of the tree) and defiling the same, or—*a ka mimi, ka tiko ranei te tangata raweke ki taua rakau.* But he will not succeed unless he finds the *mauri*—a very improbable event. If he does not find it, then his base act turns on him and rends him, for the *tapu* of the tree will kill him—that is to say, the gods of the priest who rendered the tree *tapu* will destroy him. He will surely perish ere long, unless he goes to that priest who is the medium of the destroying gods and prevails upon him to save his life. He alone can save it. *Katahi ka hikaia e te tohunga, a ka ora.* Then the priest will perform a rite, and so preserve the man's life.

A tree at Te Wera-iti named Te Rua o Tane, a *tutu*, has this *tapu* power to destroy man. Only the owner of the tree, Te Pou-whenua, grandfather of Te Whenua-nui, could save the man's life.

Concerning the right to take game on alien lands: In former times, when a man received permission to take game on lands to which he had no claim, he would set aside a portion of the game taken thereon and convey it to the principal chief of the people to whom that land belonged. Even though such tribute was not accepted, he would act in the same manner on subsequent occasions. If the tribute was accepted it might give the person a right to live on such lands, or be construed in that manner.

When Paitini was shooting birds for the opening of the carved house "Rauru" at Te Whakarewarewa, he procured many of them on land to which he had no right, but which belonged to his niece and others. Hence, at the close of the season, he gave them a double-barrel breech-loading shot-gun. It was accepted, and he now considers that he has the right to again take birds on that land.

Paitini also tells me that, if he went to Maunga-pohatu (his mother was of Ngati-Maru of that place) and found the products of the land being prepared for visitors, such food would be first offered to him, as a matter of form, although he would not accept it. Such food would then be handed over to the visitors. The people of Maunga-pohatu are the only Natives hereabout that still keep up this old custom.

In some cases people might have a right given them to take game on certain lands without that right giving them any *mana* over the lands. Sometimes a person (or persons) would be given the use of a certain snaring tree or trees, or of a rat-run, when he had no right to the land. Descendants of such persons are sometimes given shares in such lands when they are put through the Native Land Court, but this course would be optional with the owners. (My informant might have added to the above that such descendants often try to establish a claim to such lands in the Native Land Court on the grounds that their ancestors were *owners* in the block.)

All children, including those of polygamous or slave wives, had rights to their parents' lands. The father would apportion his fishing-rights, bird trees or troughs, *wai tuhi*, *wai tahei*, rat-runs, &c., among his children, a forest ridge to one, three or four snaring-trees to another, some pigeon-troughs to another, and so on. His fishing-rights and rat-preserves would be divided among his children in a similar manner. The first-born son often received the largest share, as he possessed the greatest amount of *mana* over the land—that is, in most cases, but not always so. *Mana* over land depended much upon the individual, it was a variable quantity: "*Ka rerere nga mana.*" For instance, an eldest son might be a famous warrior and spend much of his time in fighting tribal enemies, and be content with his *mana* as a warrior, having little to say in matters pertaining to land: "*Ko tona toa he whenua mona.*" His fame as a fighter would be his land. In such a case, those of his younger brothers who became adept at fowling, trapping, and cultivating would have greater *mana* over the family lands, even though they be children of a polygamous wife.

The apportionment of bird-preserves, &c., sometimes led to disputes, but the most important thing for the apportioner to do was to publicly announce his decision and arrangements to the village community or sub-tribe. For this was the *Gazette* notice of the Maori of yore, a custom that yet obtains here.

You will thus observe that a person could only take game on land belonging to his family. He could not trespass for such a purpose on the lands of another family group or subclan. When Te Uoro came from Whakatane to Rua-tahuna and asked permission of Maro to take game in those parts, he was denied. Moving on to Kaka-nui, he was allowed by a forebear of Paerau to trap game on the lands extending from O-hira-moko to the Huia-rau range. While exploring the summit of Huia-rau one fair morn he met Puke-hore, of Ngati-Ruapani, the people of Wai-kare Moana. These two discoursed a while, and Te Uoro hung his weapon on a tree hard by; hence that spot has since been known as Te Whakairinga—or, in full, Te Whakairinga o te Patu a Te Uoro, which is quite a name. Te Uoro went with his new acquaintance to his home on the shores of the Sea of Wai-kare, where, in days that followed, he married his host's daughter Te Amohanga. Their descendants are yet in camp near unto the Great Kuri of Meko.

When trouble arose at Turanga anent the slaying of Tupurupuru, Kahu-tapere and some of his people were compelled to abandon their homes and seek new ones. A priestly adept of the party, who was a *tuku matatuhi*, or seer, said, "Let us fare northward. I have beheld a vision of a fair land

and a *kahika* bush which shall be a home for us." Even so they came to Ka-pu-te-rangi, at Whakatane. Tai-whakaea was the chief man of that place. He was of Ngati-awa. He gave the migrants some flax wherefrom to fashion nets for the taking of fish. They said that they did not understand such work. Then the seer asked, "Whose is that land yonder on which the *kahika* wood stands ?" The chief replied, "If you mean that as your home, then your home shall it be." The seer remarked, "In a vision I beheld that wood, and knew it as a home for the migrants." That wood was at Wai-o-hou, and there those people settled.

But enough of these anecdotes: let us to—

Bird-spears.

There were two forms of bird-spears used by the Tuhoe people. The *tao kaihua* or *tao roa* was a long spear, 25 ft. to 30 ft. in length. This spear was used only for the period of the *rarangitahi*, when birds were speared on large forest-trees having widespread branches.

A shorter spear, termed a *maiere*, was about 18 ft. long. This was used throughout the season, but was more adapted for use on the smaller trees, and was employed to take birds with on trees as small as the *mako* and even the *poporo* shrub.

These spears were made from the *tawa* tree, and were carefully preserved, being handed down from parents to children. Many received special names. Two long *tao kaihua* so preserved by Ngati-kuri of Rua-tahuna were named Owha and Koamai-tupeka. These two spears were a great length. I came across them in the forest at Rahitiroa about 1898. They were hanging from a tree-branch. On trying to purchase them some time later, I found that they had been destroyed by children. I was not allowed to slay those children.

The shorter spears were often used for taking the smaller birds, as the *koko*, bell-bird, &c., while the long spear was used for pigeons. The long spears were not all of the same length, neither were the *maiere*. The length of a spear would be decided by the state of the balk of timber out of which it was hewed. A *tawa* tree might be felled that showed a clean trunk externally of 30 ft. or 35 ft., or possibly even longer. This trunk would be split down through the middle by means of wedges and beetle. The half showing the cleanest and straightest grain would again be split down the middle; then the best quarter would be selected from which to hew out a spear. It was essential that the timber be quite sound, clean, straight-grained (*aritahi*), and free from all shakes, knots, or other defects. The wood of the centre of the tree was not utilised for spear-making, but only the *ngako*—that is, the white, light timber between the *iho*, or heart, and the outside. Now, when a tree was split open it was often found to show defects that necessitated cutting off some feet at one end. Hence a log of 35 ft. might not turn out a spear of more than 30 ft. in length, or less. These bird-spears were made from *tawa*, on account of the lightness of that timber when seasoned. But it is not a durable wood—it soon decays if exposed to the weather; hence great care was taken to house the spears when not in use. When in use they were kept in the forest, suspended from a tree, so that the long pliant shaft would preserve its straightness. A fowler would so hang up his spear after a day's spearing. When the spearing season was over, the spears would be taken home and placed in a house, usually suspended from the rafters, the barbed head being first taken off and put away, to be fastened on again with new lashings the next season. These bird-spears are termed *here* among some tribes.

In order to hang a spear up to a tree, a small hooked piece of wood, a piece of a branchlet, was tied on to the shaft near the point end. This hook was called a *pekapeka*. Also, when climbing up a tree, the fowler would thrust the spear up and hook it on to a branch, thus leaving both hands free for climbing. The *pekapeka* is attached merely by a small cord, and is detached in a moment when the spear is about to be used. Care is taken not to allow the spear to lie, or be put away, in a bent form, or such bend would be liable to become permanent and much impair or destroy the usefulness of the implement. So long and slight were the shafts (about 1 in. in thickness) that, when spearing birds, the manipulator had to rest them on the branches as he thrust them slowly forward towards the bird. When the point was near the bird, the fowler, by a quick forward thrust, impaled the bird upon the long thin *makoi*, or spear-point. Birds were always speared in the breast or, at least, such was the aim of the fowler.

The butt end of these spears is called the *hoehoe*. The thin, barbed point or head of the spear is termed *makoi* by the Tuhoe people, sometimes *tara*. Some tribes call it a *kaniwha*. *Tara* means "a point," and *taratara* "notched." *Makoi* seems to have a similar meaning, as a comb is also known by that name. The head of the spear, just where the point is lashed on, is styled the *matahere* (first two vowels long). "*Ko te tao wero manu ka mahia ki te tawa, he mama hoki. Koia ra i kiia ai he tawa rau tangi, mo te mahinga hai pena.*" (Bird-spears were made of *tawa* because of the lightness of that timber. Hence that tree was called *tawa rau tangi* [murmuring- or rustling-leaved *tawa*], because it was used for that purpose.) Thus old Paitini. The above may be a natural sequence to the primitive mind, but it is too abstruse for *pakeha* mentality.

The *makoi* or spear-points were made of *mapara* (hard, resinous heart-wood of the *kahikatea*), of *maire* (a hardwood), of human bone, rarely of greenstone, and in latter times of iron. Temporary unbarbed points were sometimes made of *katote*, the hard black part of trunks of tree-ferns. The greenstone points were very rare: only one is recorded in this district—viz., the one from which the hill-peak Tara-pounamu was named. This one belonged to Tamatea-kai-taharua, a gentleman who flourished about two hundred and fifty years ago. He speared a pigeon at that place one day, and, the point becoming detached from the spear-shaft, the bird flew away with the point sticking in its body. But the agile Tama is said to have followed that nefarious bird even unto far Putauaki, fifty miles away, where he recovered his *tara pounamu*. This tradition is undoubtedly true, for Tara-pounamu hill still stands to prove it.

The favoured material for spear-points in former times was human bone, the long bones of the thighs. The bones were those of enemies slain in battle. I bought two such *makoi* of human bone from Ngai te Riu, of Ruatahuna, paying a bag of flour for them. They had been fashioned from bones of members of Ngati-Ruapani, of Wai-kare Moana, slain during the fighting at that place in the early part of the nineteenth century, when Tuhoe came down like a wolf on the fold, his cohorts gleaming with purple and gold—or, at least, with war-paint.

When the Natives began trading with Europeans they soon found out the usefulness of iron. Pieces of bar iron were much sought after for the purpose of fashioning from them points for bird-spears, by means of filing. Iron gridirons—the old-fashioned kind—were highly prized, the bars thereof being filed down into barbed points. One such lying now before me is 11 in. in length; another obtained was somewhat longer. The one in my possession is ¼ in. wide at the butt or lower end, and tapers (*koekoeko*) gradually to a fine point, a flattened point. The butt end is flat on one side that it may fit on the flattened end of the spear-shaft, where it would be lashed on. When the outer side of the base of the *makoi* was filed down, two slight ridges of the iron bar were left, one at the extremity and one an inch from it, so that the point could not be pulled free from the lashing. The barbs were formed in like manner as the bar was filed down. There are ten barbs, which also decrease in size towards the point of the *makoi*. These barbs are arranged in sets of two and three, points of barbs about ½ in. apart, but the space between the sets is from 1 in. to 1½ in. These spear-points are admirably made, as were those of bone and hardwood fashioned during the Stone Age of the Maori.

Tarewa-tao is the name of a *rimu* tree that stands on the Purenga Block. It was so named because in former times fowlers were in the habit of hanging their bird-spears thereon. The trunk of the tree being concealed from view by a dense growth of climbing plants, the spears were thrust up through this growth, and were so hidden from view.

Tuhoe always lashed the *makoi* firmly on to the spear-shaft. I had read Heaphy's account of a spear-point that was detached by the struggles of the transfixed bird, and hence made inquiries. I have seen such an apparatus among the Indians of the Pacific Coast north of California, who use such in salmon-spearing. The point was lightly bound to the shaft, and was detached by the struggling fish, which could not, however, escape, because the point was connected with the shaft by a loose cord or lanyard.

In the "Transactions of the New Zealand Institute," vol. xii, p. 35. Colonel Heaphy gives an account of his accompanying a party of Maori bird-spearers into the forest at Belmont, near Wellington, in 1839. He says, "The spears are about 12 ft. long . . . The point of the weapon is of bone, and barbed. This bone is hung securely by a lanyard at its base to the spear-head, but when ready for use is lashed with thin thread alongside the wood. The wounded bird flutters with such force as would break the spear were the whole rigid, but as arranged the thread breaks, and the bird on the barbed bone falls the length of the lanyard, where its strugglings do not affect the spear, and it is easily taken by the fowler's left hand. . . . The spears were very slender, not more than half an inch in diameter at thickest part. . . . This mode of capturing birds, very soon after our arrival (in 1839) went out of vogue. The spears were exceedingly difficult to make, and the few that were finished were eagerly bought by the whites as curiosities."

The spears here mentioned were very short ones (12 ft.), and much more slender than any I have seen, which were about 1 in. in thickness, and none shorter than about 18 ft. The colonel states that the pigeons were very tame, and were speared on low trees, the spearers "sometimes even ascending the lower branches of the tree." This was poor spearing. Tuhoe and other tribes, with their long spears, climbed to near the top of high forest-trees when spearing birds. I distinctly remember an old Native living at Wai-kohu, Poverty Bay, in 1874, who used one of these long spears for taking pigeons in the little bush at Puke-matai. He was camped with two Ngati-Porou sawyers, Hare and Mokena, who were cutting out the Lorne homestead. This old chap had a rude ladder (*rou*) fixed on the trunk of a lofty *kahikatea*. He used to climb up to the upper branches thereof and squat on a limb to practise his sylvan art. He kindly offered to teach me how to spear birds; but the base of operations was too near heaven for my fancy.

But about the *makoi maunu:* In answer to a query, Mr. Percy Smith said, "The bird-spears were in use in Taranaki as late as 1857 or 1858, as I have been with the Maoris when they used them; but I cannot remember the lanyard and loose head to the spear."

I then wrote to Tamati Ranapiri, of Ngati-Raukawa, about the matter. He replied that he had never seen or heard of the loose point and lanyard, adding, "*E he ana te korero nei kei te kapokapotanga o te manu ina tu i te here, ka maunu te tara i te houhanga atu ki te here. Kaore, e he ana tena. He mea tino hohou te tara ki te here, kia tino mau.*" (Quite wrong is the remark that the fluttering of the bird when speared causes the point to become detached from where it is lashed to the shaft. Not so; that is wrong. The point is lashed securely to the shaft.)

Some time after the above episode I received another letter from Ranapiri, who said, "Friend, after I had sent my second letter to you I met Alfred Knocks, of Otaki, and handed to him the letter you sent me inquiring about bird-spears, and he at once said, 'The remarks of that European (Colonel Heaphy) are quite correct.' He explained that when a lad he lived with his father at Wai-kanae. He was about ten years of age when one day he accompanied Major Edwards on a pigeon-shooting trip. They came across Wi Parata spearing pigeons up on a *karaka* tree, and he noticed that the bird-spear used was one with a detachable point, as described by Heaphy. He said also that the spears used by the Natives at Otaki in those days were quite different, the point being a fixture, lashed securely on to the shaft."

This would seem to show that this manner of manipulating the bird-spear was employed only by the Atiawa Tribe, who lived at Wellington and Wai-kanae, and not by Ngati-Raukawa.

A fowler would but very rarely allow his spear to leave his hand when spearing a bird, but only when he could not quite reach the bird with the point of it and at the same time the spear was in a horizontal position, resting across several branches, so that there was no danger of it falling. He might then allow it to leave his hand as he made his thrust at the bird. *Ka kohema atu te tao* describes the action.

These long spears were so slender and pliant that they could only be used with a rest, the branches of the tree being used for that purpose. In travelling through the forest, they were held by the point and trailed behind the bearer.

When about to make a bird-spear the Natives always selected a tree that stood well within the forest, and not one growing on its outskirts, as the latter are more difficult to split, and the timber not so easy to work—a fact known to all bushmen. The time and labour expended in making a long bird-spear must have been appalling, when we remember the crude tools of stone used by the Maori. Mr. S. H. Drew, in a letter to the *Whanganui Chronicle* (in 1898), said, "Bird-spears were made that took years to make. Fancy, if you can, the patience as well as skill required to cut a spear 30 ft. long out of a tree. The tree had to be felled with stone axes and fire, and this long 30 ft. of lance must be as straight as an arrow and about 1 in. in diameter. Imagine the labour in chipping and paring down the tree to the size wanted, with stone tools. One false stroke and the work of months would be wasted. We have two of these long spears in the

Whanganui Museum, presented by Mr. Annabell—the only two, I think, that have been saved in the colony."

In vol. x of the "Transactions of the New Zealand Institute," Mr. Coleman Phillips speaks of long bird-spears made out of *rata* vine: "The pigeon-spear was made out of a piece of *rata* vine 30 ft. to 40 ft. in length, and more resembled a stiff piece of rope than a spear, it being perfectly flexible. . . . . The head of this spear was formed out of one of the human leg-bones (fibula), both sharpened and jagged."

Enough of bird-spears. Pass we on to—

The Kereru, *or Pigeon, and how it was taken.*

The pigeon was taken in former times by the following methods—spearing, *tahei*, and *tutu*; the two latter being methods of snaring. The mode of spearing has been explained. When speared in the breast the bird is helpless, and is easily secured. The expressions *umanga* and *tarauma* are both applied to birds, and are evidently connected with *uma*, the breast. For the breast is the most important part of a bird—most of the meat is on the breast. A bird is sometimes alluded to as *tarauma nui*, or big breast. *Umanga nui* is used also in other senses: *Te umanga nui o nehera ko te whawhai* (Fighting was the important item in ancient days).

The system of snaring known as *tahei* we have noted. A number of snares (running-loop snares) are fastened to a cord termed *takeke*, which is fastened to the branches of a tree. Great numbers of these loop snares would be arranged on a single tree. Again, snares were set for pigeons over the water of a *wai tuhi*. For pigeons (and other birds) get exceedingly thirsty when feeding on such food as berries of the *toromiro* tree. They frequently adjourn to adjacent pools or streams in order to drink, and the Maori took advantage of this habit. Small streams or pools would be covered with fronds of tree-ferns, save at suitable places for snare-setting, where rows of snares were so arranged that the birds put their heads through the slip-loops in order to drink.

The *tutu* method differed from the above, for in this case the snare was arranged on an artificial perch attached to a pole. This perch was termed a *mutu*, and when a pigeon alighted on it the watchful fowler pulled a cord and caught it by the legs. This process will be described more fully when we go forth to snare *kaka*. The *mutu kereru*, or portable pigeon-perch, was smaller than a *mutu kaka* and like a *mutu koko*. A tree on which birds are taken by this method is termed a *tutu*.

We have seen that a snare is termed *mahanga* in its entirety, but the specific term for the running noose alone is *tarahanga*:* "*Koinei te tarahanga, ko te porohitatanga o te ti i mahia hai urunga mo te upoko o te manu, e mau ai te manu, ara hai kuhunga mo te upoko o te manu.*"

Waka Kereru (*Pigeon-troughs*).

We have seen that, in former times, any little pools of water lying in hollows of trees, logs, or rocks that were resorted to by pigeons as drinking-places were noted by fowlers and surrounded by a line of snares. These places were termed *waituhi* and *ngongo*. Now, the *waka kereru*, or pigeon-troughs, served a similar purpose. They were wooden troughs about 4 ft. long, hewed out of a piece of wood about 9 in. wide, the trough or hollow being, say, 5 in. wide and 3 in. or 4 in. deep, running nearly the whole length of the timber. Durable timbers were preferred for such troughs, such as *totara*. These troughs were set up on ridges where pigeons gathered to feed on berries of the *toromiro* tree. They were put up on the tops of two posts about 5 ft. high, or were placed up in trees, sometimes secured on a sloping tree-trunk. They were filled with water, and were soon discovered and resorted to by the pigeons, because the *miro* berries make them exceedingly thirsty. Many loop snares are set all round the edge of the water, so that the birds thrust their heads through these slip-nooses as they drink, and are so caught.

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* Also *tari*.

These troughs were kept filled with water during the time that the pigeons were feeding on the berries of the adjacent *toromiro*. They were visited every morning by the owner, who secured the snared birds and rearranged the loops. When giving evidence in the Purenga Block case, Tamarau Waiari mentioned a famous *ngongo* near Te Rua-kuri, and said that it formerly belonged to an ancestor named Tama-ki-waiari, adding, "At that time the custom of making drinking-troughs for pigeons was unknown in this district. It was introduced from the Wai-kato about the year 1839."

In travelling through this forest country one often sees these troughs, but they are seldom used now. I saw a few in use at Rua-tahuna a few years ago. Some of the old troughs are carved at each end, and many of them had special names assigned to them, such as Te Rua o Tarati, a trough at Huanui, on the Wai-potiki Block.

A peculiar custom obtained in former times of repeating a charm in order to cause the birds to become thirsty and so resort to the drinking-places, troughs, *wai tuhi* and *wai tahei*, where snares were set. This act was called a *whaunu*, which term seems to equal *whakainu*, to cause to drink. "*He whaunu ki nga manu o te ngaherehere kia hiainu, kia haere mai ki te inu. He mea karakia.*"

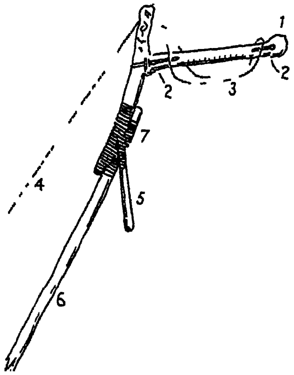
It takes an adept to fix up a pigeon-trough, to arrange the *arorangi*, *paepae*, *turuturu*, *tekateka*, *takeke*, *whakamaru*, and *mahanga* so that the birds will readily use it.

If a person, in traversing the woods, comes across a bird-trough with some snared birds thereon, which trough belongs to another person, he will, if a cautious character, pluck a branch and stick it in the ground near the trough, to show that, although passing by, he had no felonious intentions in visiting the place. This act is termed a *tapui*.

Taking the Kaka.

We have already given many notes concerning this bird, but have to say something now about the methods of taking it. There are three modes of taking the *kaka*—viz., the *tutu* process, the *pae* method, and spearing. The latter has already been explained. The *tutu* is similar to the like method of taking pigeons, but the *mutu kaka* is larger than the *mutu* used for pigeons and hence termed a *mutu kereru*. Illustrations of these *mutu* or perch snares may be seen in "Maori Art." This *mutu* is a carefully made perch on which a snare, a running noose, is arranged. When a bird settles on the perch, the long cord attached to the noose snare is pulled by the fowler, and the bird is caught by the legs.

There are four different kinds of *mutu kaka*, each one differing from the other three in shape. These are the *kapu*, *porae*, *huanui*, and *kira*. They are made from forked branches, but are cut down to the desired size and carefully shaped, showing no bark whatever. A rough perch, with the bark left on, is not termed a *mutu*, but a *pewa*—of which more anon. In making a *mutu* the main branch is cut about 8 in. or 9 in. long, and serves as the upright portion (though not always straight) of the apparatus, to which the end of the *kokirikiri* rod is lashed. This piece is so cut that the branch growing out from it, which serves as the perch for birds, is from ¾ in. to 2½ in. below the head of the upright. If you place a capital T on its side, thus, ⊢, it will give you a crude idea of a *mutu*. The shank of the letter is the perch, and its head represents the upright piece. The lower part of the head of the letter is where it is lashed to the pole. A small knob of wood is left on the lower part so as to render the lashing more secure; it prevents any slipping. The *mutu* known as a *kapu* has a curved perch, concave; hence its name. The *porae* has also a curved perch, but the bend is upwards. The *huanui* has a straight perch, which is sometimes almost at right angles to the upright, but usually slants upwards, forming, where it is connected with the upright, a somewhat acute angle on the upper side. But few *mutu* are so constructed that the perch is at right angles to the upright, as such are only used to place on a vertical pole (*hiwi*) above the fowler's head as he stands on his platform. The *kira* perch is used for shy birds, the perch forming a very acute angle with the upright.



Mutu Kaka.

1. *Toretore.* 2. *Ngingita* 3. *Tohi.* 4. *Kaha.* 5. *Pekapeka.* 6. *Kokirikiri,* or *tia haere.* 7. Lashing.

The process is as follows. The fowler proceeds to a tree used as a *tutu*, and the same trees are so used year after year. He has some apparatus for climbing the tree, which apparatus is renewed or strengthened each season. It may be a rude ladder (*rou*) lashed to the trunk, or a bridge or ladder of long poles and connecting ties or cross-pieces, constructed from the branches of an adjoining tree across to the *tutu* tree. He ascends his tree and stations himself on a rude platform, termed a *papanui*, which is erected on and secured to the branches. It is probably situated near the centre of the tree-top—that is, near the trunk—from whence he can manipulate several *mutu*. Or there may be two fowlers on one tree, each operating several perches.

Now, on this tree there are a certain number of poles of *mapou* or *totara* lashed in a permanent manner to the branches with lashings of the durable *aka-tea*, a climbing plant. These poles are termed *hiwi*, and their ends project outside the foliage of the tree. The upper end of each pole is notched, *he mea tokomanga a runga.* A few of these *hiwi* are secured in a vertical manner, but the majority are placed at various angles. Some are at such a low angle as to be not far from horizontal. It is on these latter that the *mutu* known as *kira* are used, which explains the peculiar angle of the perch already noted—it is that the perch be horizontal. These *hiwi* are termed *pouaka* by some tribes. Where a sound dead branch of the tree happens to project in a suitable manner it is utilised as a *hiwi*, being termed a *hiwi ariki*. Each *hiwi* has its proper name, according to the angle at which it is placed, and each one has its own form of *mutu* for use thereon. A *hiwi* placed in a vertical position is termed a *pou tauru*, and sometimes *pou whakaara*. The *mutu* termed a *porae* is used on this pole. The *hiwi* used for the *kira* perch is longer than others, so that it may project further from the tree. For this is used for taking shy birds, which are generally female birds (*karawa*), says my informant. Thus the *kira* perch is also attached to a longer rod than are other perches.

Each *mutu* or perch is lashed on to the end of a light rod termed a *kokirikiri* or *tia-haere*. This rod is of considerable length. A small stick is secured in the lashings so that it forms a crotch, termed a *pekapeka*. The perches were, before being used, always exposed to the weather for some time, that they might acquire an old, weatherbeaten look, otherwise the birds would not settle on them. They were usually made of *maire*, or *kahikatea*, or *totara*. Many of these *mutu* were ornamented with carvings, the upper part of the upright piece often carved into the form of a grotesque head. There is often some carving on the knob (termed *toretore*) at the outer end of the perch. The perch is sometimes notched lightly (*whakakaka*). Four holes are made in each *mutu*. One is bored through the upper part of the upright piece, and through this passes the snare-cord. Another is pierced through the end of the perch, just under the knob. Pieces of *aka* (vines or thin roots), or the quill of a feather, are inserted in this hole, the two ends left projecting an equal distance on either side. These ends are then bent forward along the perch and there secured by a slight lashing. At the base of the perch a hole is made in each side of the upright, and similar pieces of quill thrust therein. These *ngingita*, as they are termed, are for the purpose of holding the loop snare (*tohe*) in position until it is pulled therefrom by the fowler when he snares a bird.

The name of the permanent poles (*hiwi*) lashed to the branches of the snaring-tree is an expression having two meanings, as bearing on our present subject. *Hiwi* means "old-looking, weatherbeaten," as of timber or other items, and also it equals *kohiwi* as implying a hard core or heart. A tree or branch from which all sapwood has decayed and fallen, leaving merely the hard, sound heartwood, is so termed. I heard a Native say, "*Whakairia te mutu kia hiwia.*" He was speaking of a new snaring-perch, and meant that it should be exposed that it become old-looking. The permanent poles were probably termed *hiwi* because dry *hiwi* branches of trees were first used for the purpose.

Behold, then, our merry fowler ensconced upon his stage far up among the branches of a mighty tree. He has with him his *mutu kaka* or parrot-perches of four different forms, each lashed on the end of a light rod. He proceeds to arrange the snares thereon and place them in position. The running noose which forms the snare is a light cord of two strands. Each strand is made of twisted flax-fibre, and the two strands are then twisted together. This loop snare is called a *tohe*, and *whakatohe* means the making and arranging of the snare. The snare is arranged by laying it along on top of the perch and allowing it to hang down on either side. The free end of the cord is then passed through a hole in the upper part of the upright piece of the *mutu*, and to it is attached a long cord of twisted flax-fibre, termed a *kaha* by Tuhoe, but *aho* by some tribes. In order to prevent the snare from being disarranged it is pressed in under the four *ngingita*, two on each side of the perch. Both *kaha* and *tohe* have been hung in smoke for some time, which causes them to last two seasons. If not so treated, then they last only one season.

The snares being fixed, the fowler proceeds to elevate the *mutu* upon the *hiwi*. He takes up one of the *kokirikiri* (rods)—one that has, we will say, a *porae* perch lashed to it. The perch of this *mutu*, although curved, may be said to be at a right angle to the upright part, hence it must be put on a vertical *hiwi*, or *pou tauru*. The operator thrusts the rod up until the crotch near the perch reaches the top of the *hiwi*, or permanent pole. He allows the crotch to settle in the notch or fork at the top of the *hiwi*. Thus the rod is suspended from the pole, and the perch, with its snare, projects above the top of the *hiwi* pole. The lower end of the rod is within reach of the operator on his platform, and the long cord also hangs down within his grasp. The other rods and attached perch snares are then suspended from their respective *hiwi*, the butt ends of the rods and the cords being within reach of the fowler.

When a bird settles on one of the perches, the operator seizes the cord thereof and gives it a smart pull. The downward tug on the cord plucks the loop snare from under the *ngingita* and jerks it quickly upwards towards the hole through which the cord passes. But the descendant of Tu-mataika is standing on the perch. *He aha koa!* The saints cannot save him. The *tohe* or looped cord catches him by the legs, above the claws, and rudely yanks him up against the upright. That *kaka* is doomed to swift, awful, and certain death. He will make no " hot-foot get-away."

Having pulled the cord, the fowler grasps the lower end of the rod, and, lifting it clear of the forked *hiwi*, takes it down. To keep the cord taut and so prevent the bird's escape he either keeps the strain on the cord with his hand, or fastens it round the base of the rod. He grasps the *kaka* by the back of the neck, high up, to avoid being bitten by it, and kills it by biting the top of its head, thus crushing the skull.

The term *whakakatohe* means "to arrange the snares"—apparently a synonym for *whakatohe*.

This method of taking *kaka* is still employed at Maunga-pohatu, in the interior. I saw a Native taking *kaka* in this way at Rahiti-roa a few years ago. He sat on the ground at the base of the tree, smoking his pipe, waiting for Tu-mataika to settle on a perch. His cords were very long, 50 ft. or 60 ft., so as to reach the ground.

We have already shown how these fowlers utilised decoy birds when snaring *kaka*. The best decoy for the *tutu* method is a *tarariki* (or *tatariki*). The best for the *pae* method is the *tata-apopo*, a male bird. Female and common *kaka* are too timid to make good decoys. They become alarmed when many birds collect, with much noise, to the spot; they do not act as they should, scratching the ground, or gnawing at a bone or something similar.

The pigeon and *koko* are taken by the above method, but not to the same extent as is the *kaka*. The latter bird was principally taken by the above *tutu* process, whereas pigeons were mostly taken by the *tahei* method and troughs. The *koko* was taken by *tahei* on trees, but not on drinking-troughs.

The *mutu* is termed a *tumu* by some tribes.

No decoy birds are used in taking the pigeon and *koko*, for they would be useless. The decoy *kaka* attracts others either by scratching the ground and acting as though finding an abundance of food thereby, or by screeching, or gnawing at a piece of bone provided by the fowler. These decoy parrots were provided with a perch of hardwood, to which they were secured by a cord round the leg, which, however, gave them liberty to walk up and down their pole perch. Were this perch of soft wood, then the parrot would soon demolish it with his powerful beak.

The act of pulling the cord that snares a bird on a *mutu* is described by the word *takiri*. "*Ka mate takiri kaka, ka ora karikari aruhe.*"

The Pae *Method.*

Among some tribes this method is styled *taki*. It is conducted not at dizzy heights on huge forest-trees, but on the ground. At a suitable spot, selected by past-masters in the wiles of the fowler, a pole is secured to two trees, and another pole is placed with one end against it and the other resting on the ground. This latter slanting pole is placed at such an angle as will render it easy for a *kaka* to walk down it. At the base of this *pae* a small shelter is erected as a means of concealing the fowler—who squats within it—from the birds hovering overhead, or descending the pole. The booth is made by sticking branches in the ground and covering them with fronds of tree-ferns. The decoy *kaka* is secured at the base of the sloping pole, where it employs itself, if well trained, in scratching among the leaves and rubbish on the ground, or in gnawing at a piece of bone, and making the harsh sounds peculiar to these birds at such times. The other *kaka* are attracted by the cries of the decoy, and come hovering overhead. They see the decoy scratching out food, apparently, on the ground, or hear it gnawing at the bone. Gradually they come nearer to take part in the feast. Some settle on adjacent trees and watch the decoy, some descend and settle on the cross-pole. At last one begins to walk down the slanting pole. As they slowly descend the *pae* these birds always keep turning from side to side. When the bird at last descends the pole to a point opposite the shed, the fowler takes advantage of the right moment, when its head is turned away in the other direction, and quickly grasps it, pulls it inside his shelter kills it, and waits for another to descend. If the fowler does not possess a decoy bird he has to decoy one himself, which he does, in the case of the *kaka*, by imitating its cry, but not using a call-leaf, as is done in many cases. He will utilise the first bird caught as a decoy.

We will now describe another kind of *pae*, whereon such birds as the *koko*, *tihe*, *rearea*, *tieke*, *kokako*, and *tataeto* were taken.

Taking the Koko.

This bird was taken by six different methods—viz., the *pae*, *tutu*, *tahei*, *maiere*, *puna wai*, and the *whakamoe*.

This *pae* is a pole fixed in a sloping position to two trees or upright poles fixed in the ground. It is erected at a suitable place in the forest, and at the lower end of the perch is erected a small shelter for the fowler, as used in the case of the *kaka*, to conceal him from the birds. The fowler is armed with a stick termed a *hauhau manu*, or "bird-striker." It is a round, smoothened piece of white *manuka* about 5 ft. in length, which, when made, is hung up in a hut over a fire to season, *kia pukeko, ara kia tawhito*, as my informant put it. No decoy, either a *mokai*, as in taking the *kaka*, or *maimoa*, as in taking the *pihipihi* and *porete*, is used. The fowler relies entirely on the *pepe*, or call-leaf, in order to attract the birds and induce them to settle on the *pae*. A leaf of the *raurekau* tree is used for the purpose. The wily fowler squats within his shelter, stick in hand, and imitates the cry, or one of the cries, of the *koko*, or whichever of the above-mentioned birds he is desirous of taking. The striking-stick is held resting against the perch pole, and when a bird alights on the latter the fowler strikes it down with a vigorous sweep of his stick, which runs along the side of the perch.

As for the *tutu* mode of taking the *koko*, it is the same as for the *kaka*, save that the *mutu* or perch used is smaller, and has sometimes some light-coloured moss or lichen attached to it in order to increase its resemblance to a dry tree-branch. The *tahei* method has been described. As for the *maiere*, or spear, the *koko* is taken in this manner at times when it cannot be attracted by the call-leaf, as is the case when it is feeding on the berries of the *mako*. The *puna wai* (water-spring) is another striking method. The fowler selects a pool of water or a stream in the forest whereat these birds are in the habit of drinking. In the case of a creek, he leaves a suitable pool, and covers the rest of the water for some distance with fronds of tree-ferns, so that the birds will come to drink at the space left open for them. A pole is stuck in the ground so as to lean slantingly over the water-hole, and near the pole a rude shelter conceals the fowler. The birds come early in the morning to drink, and alight on the sloping pole, from which they are struck down by the fowler's stick. It will be observed that in all these striking methods the pole serves two purposes—not only is it a perch for the birds, but also a guide for the stick (*hauhau manu*) when the blow is delivered. In making the strike, the stick is run along the pole perch.

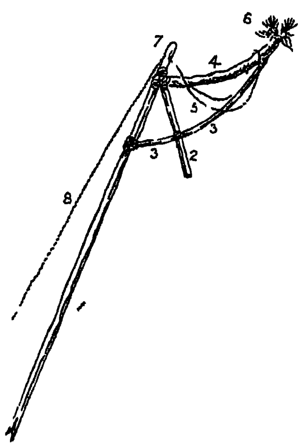
About the *whakamoe* method of taking the *koko*: This was practised on frosty winter nights, and was a mere taking by hand, the birds being so benumbed by the cold that they made no attempt to escape. Fowlers go forth into the forest in the evening in order to locate the roosting-places of the *koko* (*tui*). When birds are so detected, the searchers back away quietly so as not to alarm them. The next thing done is to mark a trail that may be followed by the fowlers later on in the night. This marking is effected by the *pawhati*—that is, by breaking down tops of shrubs and ends of branches—not breaking them completely off, but leaving them hanging. Late in the night the men return to take the birds. Two persons usually go together. One says, "*Me haere taua ki te rama i ta taua whakamoe.*" They set forth, taking a torch with them. On arriving at the roosting-place one man remains on the ground and holds the torch, the other ascends the tree and climbs to where the birds are roosting. He then simply takes the birds off their perch by hand, and puts them in a basket he has brought with him. The birds, say my informants, do not awake or become startled. They are very fat, and benumbed with cold—affected by the frost. The intense cold paralyses them. *Ka tikona e te huka.* Should a bird fall to the ground, it will cry out, but cannot fly. The man below will secure it.

In some parts a trail is marked by means of laying down fronds of the silver tree-fern (*kaponga*) or leaves of *rangiora* or *wharangi*, the underneath side of all these being placed uppermost, as they are white, and can be seen at night, very often without the help of a torch.

When using a call-leaf, fowlers carried a number of such leaves with them. They were carried in the waistbelt termed a *tatua pupara*.

The Pewa.

This was another bird-taking implement, somewhat resembling a *mutu*. It was used for taking the *tihe*, when that bird was fat, in the winter season. It seems to have been hooked on to any tree-branch, and not on *hiwi* fixed by man, as in the case of the *mutu kaka*. A light rod, termed *ti haere* and *tia haere*, has a short piece of wood, curved like the *kapu* perch for *kaka*, attached to it near the top by a lashing. This is the *pewa* or perch. A stay-piece, called a *kake*, supports it, one end being secured to the outer end of the *pewa*, and the other to the *ti haere*. A crotch-piece, known as the *turi*, crosses the *kake*, and is secured to it and the base of the perch. This serves as a hook whereby the apparatus is suspended from a branch. A *poa*, or bait, is attached to the outer end of the perch, and consists of forest-flowers, those of a climbing-plant resembling the *rata* blossom being preferred. The *pewa* and *mahunga* (upper end of *tia haere*) have moss secured to their surfaces to make them resemble tree-branches, to appear natural to the birds. The *tohe* or loop snare and cord (*aho*) are the same as those for a *mutu kaka*, but are slighter. Moreover, there are no *ngingita* on a *pewa*. The loop is kept in place by being lapped across the underside of the *kake*. One side of the loop is brought down on either side of the perch and under the *kake*, where one bight is pulled through the other and so left. When a bird settles on the perch and the fowler pulls the cord, the *tohe* or loop is disengaged, and catches the bird just as it does on a *mutu*. A piece of a small branch of a *toatoa* tree is preferred for making a perch, as it is said that birds are very particular as to what they settle on. The *toatoa* branchlet has a *whekewheke* (rough) appearance, said to be desirable in their eyes.



THE PEWA.

1. *Ti haere.* 2. *Turi.* 3. *Kake.* 4. *Pewa.* 5. *Tohe* (loop snare). 6. *Poa.* 7. *Mahunga.* 8. *Aho.*

Such are the various ways by which birds were taken in the forests of Tuhoeland in former times. By such ingenious wiles did the Child of Tamatea secure a "square meal." He knew by long experience just how, and when, and where to take each species of bird. At any time he knew where each species was to be found, what fruit or other food it was living on, and whether or not it would respond to a lure call, or must be speared, or taken by *mutu* or *tahei*. He knew just when to lay aside the snare and take up the spear. He knew all the calls, habits, tricks, wiles, foods, and ways of the feathered Children of Tane. For stern necessity had taught him all these and many more things. It is said that necessity has no laws. On the contrary, she has a whole bunch of them.

An omitted remark: When a fowler is engaged in taking a certain species of bird by any of the methods described, do not imagine that he scorns any other species. Not so. Any bird that settles on his *pewa* or *mutu*, or comes within reach of his spear or striking-stick, is taken. All is bird to the fowler.

Mr. Colenso mentions two kinds of bird-snares that were known by the names of *whakoau* and *pare-kauae*. Another name for a perch was *taeke manu*, apparently a form of *mutu* or *pewa*. None of these terms seem to be employed among the Tuhoe Tribe.

We have seen that a feeding-ground or resort of the *kaka* is termed a *whakarua*. But few other birds are seen at such a place. A feeding-ground where several species gather, as *kaka*, *koko*, and pigeons, and frequent the same trees or place, is termed a *hapua*. It seems to depend on the kinds of trees growing at any place as to what birds will frequent it.

Birds are much easier to take at some times than they are at others. They sometimes seem to neglect precautions when on a very fruitful tree, and do not, as usual, keep glancing about and turning from side to side. At such a time they soon get fat, and one says, "*Kua tu ruruhi te manu, kaore e kanae nga kanohi, kaore e whetete.*" A *papauma* tree (*Griselinia littoralis*) at Te Wharau is a tree which is frequented by *koko* in the above manner, and they get fat on its berries: hence it is known as *turuhunga*.

COUNTING GAME.

In counting birds, or baskets of produce, the Maori always counted in pairs—that is to say, he employed the term "brace," as we do. The term for "brace" is *pu*. *Kotahi pu* = one brace. To express an odd number he had several terms, as *kehe*, *taukehe*, *tautahi*, &c. Thus *ka rua pu*, *taukehe*, implied five birds, two brace and an odd one. But in counting *koko*, which is a small bird, four, or sometimes six, were reckoned to a *pu*. Thus a *pu* or pair became two brace, really. The expression *whakamoe* was sometimes used to denote the counting of game: "*Kai te whakamoe a Paora i nga manu o te taha.*" In former times the Maori had a semi-vigesimal system of counting: thus, *hokorua pu* was twenty brace, or forty; *hokotoru pu* was thirty brace, or sixty birds. In many cases any balance between one score and another was not specified, but a person simply said "threescore-odd" as for any number between sixty and eighty. Or fowlers would continue their snaring or spearing in order to make up an even number, as two score, or three score. But this subject of counting has been dealt with in a recent volume of the Transactions; hence we here eschew it.

PUHORE.

Now, this is a serious matter, this *puhore*. Observe: when going a hunting, fowling, or fishing, there are about five thousand items or acts which, if they occur or do not occur, if they are committed or not committed, will assuredly bring you bad luck in your venture. All these items, acts, or happenings are *aitua* (unlucky). Of a verity, their name is legion. There are also a certain number of items that are *marie*, or lucky signs. These, however, appear to be much less numerous than the unlucky ones, more's the pity. We will not pain you by giving five thousand *puhore*, but merely a few as examples, as also a few illustrations of *marie*. We will not repeat some already given in preceding pages.

If a hunter dreams that he meets a handsome woman, that is a lucky sign, as it surely ought to be. He will assuredly slay a fine fat pig, or secure many birds or fish. Such a dream is termed a *moe tamahine*.

To dream that one sees human spirits is a *moe papa*, and a *puhore*, or unlucky sign.

It is a *puhore* to yawn while fishing: you will have poor luck.

If, when going a-fowling, you stub the left foot, hurt it against a root, that is a *tutuki tamaki*, and a *puhore*.

To dream that you are travelling and see a fence across the track in front of you is unlucky.

If, when going hunting, your dog stops on the right side of the track, it is a sign of good luck; if on the left side, then bad luck awaits you. Or if a fisherman stops often on his way to the fishing-place he will have bad luck. Or if he runs into many cobwebs spun across the track he will be unlucky. If the first fish that takes the bob or hook is not landed, but escapes, that brings bad luck for the fisherman, who returns home at once—no use remaining longer. If the first fish seen (in taking the *kokopu*) is secured, it is thrown aside; not kept, nor yet returned to the water. That act will bring good luck. If the signs of ill success only affect some of the party, then those persons will quit fishing, but will carry the torches for the others.

To start in one's sleep and throw out both arms is a *puhore*. To dream that one catches two birds at once is lucky. Again, if a person partakes of *tawaka*, an edible species of agaricus, it will be useless for him to go a-birding, for he will have no luck thereat.

Kati! We will cease from quoting these signs and tokens of yore; the reader shall be spared from perusing the remaining thousands.

It is said by Natives that the *torea* (bird) knows when a storm is approaching, and at such times changes its cry to "*Keria! keria!*"

YOUNG OF BIRDS.

A few remarks: The young of water-birds, as of the *parera*, *whio*, and *weweia*, are termed *kawaiwai*. The term *kuao* (young of animals) is sometimes applied to them, perhaps before they leave the nest. "*Ka whanau nga kuao o te parera, ka haere ki te wai kau ai, ka kiia i kona te ingoa he kawaiwai.*"

The young of land-birds are termed *pi* while they are being fed by the parent birds, before they leave the nest; but after they leave the nest and are able to seek food they are called *kukari* and *hukari* until full-grown. Some say, however, that *kukari* is applied only to the young of the *koko* and *rearea* at the above-specified time. The term *punua* is sometimes applied to young land-birds: "*Ka hopukia te punua koko, ka akona ki te korero, ka whakarawa.*" The term *pitaketake* is applied to the young of forest-birds before they leave the nest.

Eggs are termed *hua*—in full, *hua manu*, or "bird-fruit." The shell thereof is *papapa*, the yolk is *toua* and *tohua* (cf. *tohua*, "to be conceived").

A bird's nest is termed *kohanga* and *kowhanga*. A fortified place, a *pa*, was also often called a *kohanga*, wherein the people dwelt in security. The dangers to life were outside the nest, a fact that came home to the famous chief Te Mai-taranui, what time he uttered his oft-quoted saying, "*He manu hou ahau, he pi ka rere,*" and sank in death by the roaring falls of Te Reinga.

The nesting-period of birds is the month Hakihea of the Maori year, which is about December.

The wings of a bird are termed *paihau* by the Tuhoe folk, and sometimes *pakihau*. Other words for "wing" are *parirau*, *harirau*, and *pakau*. The local word for a bird's tail is *kotore*, while other terms for the same are *humaeko*, *hurumaeko*, and *kururemu*; whereas the tail of an animal is *whiore* or *hiore*, and that of a fish *huki* or *hiku*.

FEATHERS.

Feathers are termed *huruhuru* by the Tuhoe people, but, as this word also means "hair," the word *manu* is often added (*huruhuru manu*) to make matters plain. Another term for "feather" is *hou*, which does not seem to be used in the Tuhoe district. Plumes, such as were worn in the hair in former times, are termed *piki*, *rau*, *raukura*, *pare*, and *kotore*. The last expression is applied to long tail-feathers used as ornaments.

The quill of a feather is called *tuaka*. The long wing-feathers are termed *kira*. The long plumes of the albatros (*toroa*) are called *makaka*. There are four long feathers or plumes in each wing of the *kotuku*. These are named the *tatarahake*, *whaitiri*, *te rau o titapu* (or simply *titapu*), and—but the fourth we are not sure of. Another authority, but not so reliable a one, says the first one is called *kapu* and the other three *kira*. The *titapu* is a *tapu* plume. Highly prized also were the very fine, delicate feathers that overlap the long tail-feathers of the *kotuku*. These are termed *awe kotuku*. Some further names are given at page 302 of "Maori Art."

THE SINGING OF BIRDS.

In speaking of a bird's note or call, a Native usually uses the term *tangi* as both verb and noun, but there are several special words to denote the singing of birds. *Korihi*, "to sing" (of birds only), is one of these, albeit I have not heard it used by the Tuhoe people. The word *ko* is used by Tuhoe to denote the singing of birds at dawn and eve (about sunset) only. It is not used to denote their singing at any other time. As a rule they emit different notes during the daytime. It implies only the grand concerts given by birds of many species at those times, but more especially the morning one. And how fine they were in former years any one who camped within our forests in the sixties of last century knows full well. Even at Rua-tahuna, four or five years ago, when the *koko* were numerous, and the bell-bird was reappearing, the morning song of hundreds of birds was a delightful thing to hear. These morning and evening concerts were called the *Mara o Tane* in former times. This use of the word *mara* (first "a" long, please) is singular.

The term *ko* is often heard here: "*Ka ko te manu, ka whakatika matau*" (When the birds began their morning song we started); and "*Kaore ano i ko te manu*" (The birds have not yet begun to sing).

The word *korohiko* seems to bear the same meaning as *ko*, but is not so often heard. Said my informant, "*Ka oho te manu i te ata, ka tangi, he korohiko tena.*" We note its use in song:—

Ko te moe a te manu
E korohiko noa ra
I te ata hapara.

Koko, to chant, apparently comes from this root *ko*, as also the bird-name *koko*, presumably on account of its song-power, which is great. An old-time saying is, "*Ko te moe a te manu, au ana te moe ki te peka o te rakau: ko te moe a te tangata tutaka rerewa tonu i te taua*" (The sleep of birds—their sleep is sound upon the tree-branch, unlike the sleep of man, ever fearing an attack). And again, "*Ma te huruhuru te manu ka rere, ma te kakahu te tangata ka tika ai*" (By means of its feathers does a bird fly; by means of clothing is man made presentable). This saying is often given a different ending: "*Waihoki ma te kai te tangata ka ora ai*" (In like manner, by means of food does a man retain life).

"*Ka nro ake ana te weka i te mahanga, e kore e hoki mai*" (The *weka* that escapes from a snare will not return). A man who escapes from a war-party will not put himself in its way again.

> Moe araara, moe araara
> Ka tau te manu ki runga ki te pao
> Kohere, kohora, ka tiritiri, ka waewae.

This item appears in some notes handed to me by Mr. G. H. Davies. It applies to the restlessness of people expecting an attack; but the last line is not clear to me.

"*Te Weraiti umu tahu noa*"; "*Te Wai-iti umu tahu noa*": At Te Weraiti, and Te Wai-iti, two forest valleys at Rua-tahuna, food, such as birds, was so plentiful that many ovens would be seen filled at one time, indicative of a land of plenty. The saying, "*He tutae koingoingo*," is applied to persons who depend on birds as a tasty relish for vegetable foods. In some seasons birds are numerous, at others they are scarce.

When fishers or hunters brought in a large haul of fish, fowls, or rats, the women proceed to *titihawa*—that is, to dance, caper about, and chant an *umere*, or song of joy. A portion of such fish or game set aside for a family or subclan is termed an *inati*. To apportion food in this manner is *whakainati*.

The origin or parent of the *weweia* bird, says Pio, was one Rukuruku. The *parera* is a descendant of Moe-tahuna; the *kawau* is the offspring of Noho-tumutumu.

PRESERVING BIRDS.

The Ahi Matiti.

In former times vast numbers of birds were preserved for future use. When the season opened, a number of birds of the first take were set aside for the ritual feast already described, but the bulk of the birds were consigned to the *ahi matiti*. When Matariki appears, then the *ahi matiti* is kindled, for it is about that time that the bird season opens.

The first process was that of plucking the birds, after which came the *makiri*. To *makiri* a bird is to take out the bones. This is always done before the birds are potted down, except in the case of small birds, as we have noted in the case of the *pihipihi*. The birds are kept a few days before being *makiritia*, as the bones are then more easily taken out—the flesh strips off them easier. The operator first grasps the wings and pulls hard at them to straighten them out. (This boning process, by the way, is generally carried out by women.) Next a cut is made round the base of the wings in order to sever the flesh. In these times a knife is used for cutting, but formerly the beak of a *kaka* was used for that purpose, and the operators' thumb-nails were allowed to grow long so as to be the more serviceable in stripping the flesh off the bones. A slit is now made down the back of the neck and the skin stripped off the neck. The lower beak of the bird is torn off and left attached to the neck-skin. The upper beak, head, neck, wings, legs, and body of the bird are all connected when the flesh is stripped from the frame. The flesh is stripped downwards off the breast, and the legs are pulled through it. The skin of the neck is twisted and tied, so as to leave the lower beak sticking out, for when the prepared birds of each person are counted, it is these bills that are tallied off. They also serve to show the species of bird—no one can palm off an inferior bird as a pigeon. People used to collect for this bird-potting work at some hamlet decided upon, and many would take part in the *makiri* work. A good deal of rivalry obtained as to who would prepare the most birds. The refuse of the birds, insides and bones (which would have yet a little flesh adhering to them) were cooked as food for the workers. The birds so prepared were packed tightly in baskets, which were put under water in a stream, where they were left until thoroughly cold; otherwise they would not keep long after being potted. The process of packing the birds in layers in baskets is termed *whakamata*. A basket of these prepared birds is termed a *poutaka;* but that name would not be applied to the basket when empty—the basket is a *kete*. *Kiwi, kereru, kaka, kakapo,* and *koko* were all preserved in the manner we are describing.

When taken from the water the birds are taken to the *ahi matiti,* the *matiti* fire, at which they are cooked and potted. Here three or four poles are stuck in the ground in an upright position, each upright pole having notches cut in it on the side next the fire. The birds are spitted on long rods, and when the first rod is full it is laid in the bottom notches of the uprights. The next rodful is placed in the next notches above the first, and so on, each layer of birds somewhat overlapping the row below it. The *ahi matiti* is a strong, clear fire, and is kept burning a little distance in front of the *matiti*, as the arrangement of rods is termed. A wooden trough is placed immediately below the rows of birds. One end of the trough is lower than the other, and under this end is placed a large wooden *kumete*, or bowl, which is sunk in the ground.

The heat of the fire melts the fat of the birds, which fat drips into the trough and runs thence into the large bowl below. Red-hot stones are placed in this bowl until the fat therein boils. The birds when cooked are taken off the rods and packed in gourds (*taha*)—calabashes. The boiling fat is then poured over them until the pot is full. The word *kohua* describes the stone boiling process. Food so preserved is termed *huahua* —*huahua manu* if birds, and *huahua kiore* if rats.

Coast-dwelling tribes used vessels made of seaweed wherein to preserve the *titi* bird, but the inland folk used the calabash for all potted game.

These birds, &c., preserved in fat have ever been reckoned a great delicacy by the Natives, and the principal item of a feast. Such food was often placed before visitors of rank, though apparently not always, inasmuch as a common saying among Tuhoe is, "*Waiho ma te pirau kainga a Te Winirehe*" (Leave it for the decrepit old people of Te Winirehe). This man was a tribal ancestor, he who smote the sons of Manawa at Oputara, and he objected to the *huahua* of his hamlet being given to visitors, and so kept it for the decrepit old folk of his home. But even he would place plenty of luscious *huahua* before the members of a party of blood-avengers who came to him as allies in war-time.

The word *matiti* seems to imply numbers, as in "*Matiti ana te haere o te koko ki runga ki te kahika.*"

When describing the work at the *ahi matiti,* a Native said, "*Tokorua tohunga kai te whaunu atu ki te ahi.*" Two adepts repeated certain charms at the *matiti* fire to cause it to have its desired effect—that the fat of the birds might melt and run readily into the trough.

There is some evidence that stone bowls or troughs were used in the north for stone boiling.

The *hue*, or gourd, was formerly grown to a considerable extent. In the *kotawa* stage of growth, when young and soft, they were eaten, but many were allowed to mature. These matured ones were used for bowls, water-vessels, &c. The bowls, formed of half a *hue* cut through the middle, were termed *ipu* or *oko*. The water vessels and potting vessels were termed *taha*. These had merely the top cut off—that is, the small end, where the *hue* had grown on the plant. The species used for *taha* grows in a pear-shaped form. The opening in the vessel is large enough for a person's hand to pass through, and is called the *ngutu iti*, or small lipped.

When a vessel is filled with potted food, the small exposed surface is covered with leaves, &c., and in rare cases a *kopani* or wooden cover or lid of carved wood was used. When brought from the storehouse to serve as a centre-piece at some feast, a carved wooden neck piece was placed on top of the vessel, which cylindrical piece is termed a *tuki*. The vessel was mounted on three or four carved wooden legs (*waewae taha*), and ornamented with bunches of feathers.

The *tukohu* method of cooking birds and rats consisted of putting them in a bowl (*oko*) and then placing the bowl in a steam oven, by which means the fat was saved. These birds or rats were so cooked either boned or with the bones left in.

In regard to the taking of fresh-water fish, and the many curious customs, &c., pertaining to such work, such notes have already appeared in the Transactions in an article on the food products of Tuhoeland, hence we will not insert them here. It was a bad arrangement to put such notes under that heading, but we bush folk are not versed in the rules of compiling ethnographical matter.

There are, however, a few fish notes that have come to hand since the above article was published. These few we proceed to give.

"The Ngai-Turanga clan, in former times, had rights to the waters only of the Tauranga (Wai-mana) River—that is, fishing rights between Otara and Okehu, but had no rights to the land on either bank, at that part."

In respect to eel weirs (*pa tuna*), but little is known of this matter by Tuhoe, inasmuch as they have no good eel streams in their district. The extensive weirs constructed in some places were made under the supervision of adepts at such work. Ranapiri, of Ngati Raukawa, says that the first post or upright stake on the right of the entrance of a weir is called the *pou reinga*. It is at this post that the *mauri* is located. After the weir is finished and ready for use, no eel pots are set for the first few nights, or the eels will cease to pass through in numbers.

One occasionally sees the double *hinaki* or eel pot, having an entrance-funnel (*akura*) at each end. The last one I saw was made of wire netting of a small mesh. May Tangaroa have mercy on the maker thereof!

The *puhi* is a species of *kokopu*, a fresh water fish. It is a very quiet fish, not easily frightened, and is easily taken. It can be pushed into the net with the foot. The *titarakura*, a small fish, is sometimes called *titikura*.

Ngaio is the name of a kind of worm, a parasite sometimes found in the *kokopu* fish. A similar parasite is occasionally found in the *kaka* bird, which is in very poor condition at such a time.

The Huna, Ari-matanui, and three Tamatea nights of the moon are deemed unlucky or unsuitable for river-fishing.

The disappearance of the *upokororo* fish from the Whakatane River is said to have been brought about by an old warlock named Kaaho, who drove them away by means of his magic arts.

The cause of the great scarcity of eels in the Rua-tahuna district may possibly be the difficulty of ascending the rapids just above the mouth of the Pu-kareao Stream.

The *upokororo* is given as *Retropinna upokororo* in the third volume of the Transactions, page 134.

Some interesting notes on eels, *papanoko, toitoi, inanga, atutahi,* and *upokororo* fish, by Captain G. Mair, may be found in vol. xii of the Transactions of this Institute. This name, *atutahi,* as that of a river-fish, is of interest, because *atutahi* is a star-name and often appears in the form of *atutahi-ma-rehua,* while Rehua is the star Antares. And Rehua is said to have been the origin of the *inanga* or whitebait. Captain Mair states that the *atutahi* is a large kind of *inanga.*

Pakarara and *kaiherehere* are given as names of species of eel.

For information concerning the fresh-water fish of Tuhoeland see vol. xxxv of these Transactions.

We here give a few belated notes on divers trees and plants that should have been inserted in Part I of these notes.

Maire.—The black *maire,* or narrow-leaved species, is termed *maire-rau-riki.* It is either *Olea montana* or *O. Cunninghamii.* The white *maire* (? *Olea lanceolata*) is here known as *maire-rau-nui* and *maire-roro.* The berries of this tree are eaten by birds.

The *houhi ongaonga* is *Plagianthus betulinus.*

The *tanguru* is *Olearia furfuracea.*

The tree here termed *tawai,* or *tawai-rau-nui,* is apparently *Fagus fusca,* while another species, known as *tawai-rau-riki,* found at lower altitudes, is possibly *F. Solandri.* Huge trees of the former species are found on the high-lying ranges.

The *tawhiwhi* is a climbing-plant which bears red blossoms. These flowers were often fastened to the perches of bird-traps as a lure, as on the *pewa.*

The *nahonaho* is a plant.

Of *Eugenia maire* Mr. Percy Smith says, "The almost universal name of this tree on the west coast of the Island is *tu-huhi,* though the people know it also as *maire-tawhake,* and better still as *whawhakou.*"

The fruit of the *tutu* was sometimes preserved for the owners by means of a *rahui,* which warned persons against taking such fruit. A grove of these trees at Ohae, Ruatoki, was known as Ure-takohekohe. It was protected in the above manner during the fruiting season, and woe betide any person who interfered with it! He would probably be killed.

Tutae-whetu should, I believe, be more properly termed *korokoro-whetu.* According to Colenso it is *Ileodictyon cibarium.*

Kahoho is another name of the *poporo* or *poroporo,* a *Solanum.*

Kekakeka is the water-plant commonly termed duckweed.

Kohuwai is a moss-like water-plant.

Kokomuka-taranga is given in Cheeseman's Flora as *Veronica parviflora,* but the species known by the former name among Tuhoe has leaves 4½ in. and 5 in. long, which does not agree with the "1–2½ in." given in the Flora.

The *kotara* I believe to be *Olearia Cunninghamii.*

The *kuwawa,* a water-plant, is *Eleocharis sphacelata.* It is also known as *wawa, kuta,* and *kutakuta.*

The *mapere* is *Gahnia setifolia.*

Leaves of the species of *Astelia* termed *mauri* were in former times woven into fillets and worn by girls.

The *raupeti* is *Solanum nigrum*. The berries and leaves thereof are eaten by the Natives, the latter being cooked as greens.

The *retoreto* is a water-plant, *Potamogeton Cheesemanii*.

The *ti para*, a cultivated species of *Cordyline*, is certainly not *C. terminalis*, says Mr. Cheeseman. The latter is difficult to rear even about Auckland, so easily affected is it by frost. The Rev. H. Williams informs me that the *ti para* of Tuhoe is found at Moa-whango. Mr. Percy Smith states that it resembles the *ti tawhiti*. Colenso mentions *ti para* as an unnamed species of *Cordyline*. A plant growing in my garden at Rua-toki has now (August, 1909) a stem about 30 in. high, and has about a dozen young plants or shoots growing up from the base thereof. The plant is four years old.

The *tumingi* is probably the same as *mingimingi*.

The *maru* (both vowels long) is *Sparganium antipodum*.

The name *upoko-tangata* is loosely applied locally to both *Mariscus ustulatus* and *Scirpus maritimus*.

The *tamatea* appears to be termed " nigger-head " by settlers.

The outside leaves of *harakeke*, *Cordyline*, and of all plants, &c., the leaves of which are termed *wha*, are called *pakawha*.

Old superstitions die hard. When a Tuhoe Native plants imported fruit-trees, he will not eat the first crop of fruit borne by such trees, but simply leaves it, or throws it away. Were it eaten, then the trees would bear no more fruit in future years, according to local belief.

We have seen that trees were measured by the *pae* method. A famous saying of Te Hau-nui is preserved by the local Natives. Te Hau-nui was annoyed by some presumptuous remark made by a person of inferior rank to himself. His word being discredited thereby, he remarked, "*Kaua e whakateka te pae tahi ki te pae wha*" (Let not the single *pae* [tree of small girth] cast discredit on the four *pae* [tree of large girth]). To which his adversary replied, "*Ahakoa to nui, he nui puwhawha*" (Though big, yet you are hollow or decayed internally). The Maori is apt at such rejoinders as the above.

The apparatus already described in Part I as having been employed for the purpose of turning over heavy logs was termed a *kauwhiti* or *tuwhiti*.

Taraumu is another name for a " scarf " in tree-felling.

The *toronu* (*torongu*) caterpillar that destroys the sweet-potato plant is *Nyctemera annulata*.

ADDITIONAL BIRD NOTES.

The *kakapo* disappeared from the Tuhoe district soon after the arrival of Europeans on these shores, and before any white folks settled near the district. Paitini, born about 1843, says that these birds disappeared before his time, which seems to mean that they were no longer seen in 1850. He says that the *kakapo*, on returning from their feeding-ground, collected at their *whawharua* to go through the performance described in Part II. This was during the night.

The cry of the *kareke* was looked upon as an omen of bad weather.

Kawau.—Young shags were taken by hand from the nest before they could fly. The species known as *papua* is probably the same as *mapua*, given in Williams's Dictionary.

Whakamoe koko.—Taking the *koko* by hand on frosty nights. Care had to be taken not to frighten these birds when searching for and marking down their roosting-places. The snapping of a stick will cause them to desert their perches. From about 3 in the morning until shortly before daybreak is the best time to take these birds by the above process. The female *koko,* or *tui,* is known by its having a smaller *werewere* (the tuft of white feathers on neck) than has the male bird. When taking the *koko* and other birds by the *pae* method the fowler is crouched in a rude shelter, and strikes the birds down with a rod (*hauhau*). These birds eat the berries of the *papauma* (*Griselinia littoralis*), and are taken by the *tahei* or snaring process on that tree at such time. The *koko* and other birds, when feeding on the berries of the *kotukutuku* in summer, were sometimes taken for immediate use, but not for preserving.

The *rimu* and *matai* are the trees used as *tutu* for taking the *koko* and *kereru*—that is, on which these birds are taken with the *mutu* or perch with loop snare.

Tuteao, of Ngati-Awa, who lived at Matahina about eight generations ago, possessed a tame *koko* named Hine-te-iwaiwa. Tuteao was expelled from that district for having slain his younger brother, and went to Opotiki. Apa-nui coveted the bird because it talked so well. Hence he slew Tuteao, in order that he might possess it. Ngati-Awa equalised matters by marching eastward and slaying Rangi-ahua.

The female sparrow-hawk is termed *kaeaea* and the male bird *kakarapiti.* Both the sparrow-hawk and the *kahu* were sometimes trapped on account of their thieving habits, making off with game from camps, and so forth. They were eaten when so caught.

A *kaka* with unusually dark-coloured plumage is termed a *kaka parakiwai.* It is said that birds of such hue were hatched in a *hinau*-tree.

Both *tionga* and *tirore* are terms applied to the first *kaka* caught and used as a decoy for the one day only. *Kaka* were not struck down with a stick in the *pae* method of taking them: they were taken by hand. The *kaka* is always much quieter and more easily taken by hand when fat. *Kaka* and *kereru* are the only forest-birds that can be caught in stormy weather. A few of the latter will be found caught in the snares of the drinking-troughs. Occasionally a *kaka* will settle on one of these troughs and be caught in a snare, but, if not caught by the neck and so rendered harmless, it will gnaw the cords and free itself. The *koko* is sometimes caught in the trough-snares, but the pigeon is the only bird that is so taken in numbers.

When not fixed up on trees, these troughs are elevated about 5 ft. from the ground on upright posts. There are four upright sticks, one at each end of the trough and one at either side. These are termed *turuturu.* The cross-pieces at the end are *arorangi.* The long horizontal sticks are called *paepae,* while the leafy branchlets put to prevent the birds from gaining access to the water at either end of the trough are known as *whakaruru.* For no snares are placed at the ends of the trough, but only at the sides thereof.

Kaka are never taken by the *tahei* method. It is impracticable, for reasons obvious to those acquainted with these offspring of Tu-mataika. The *kaka* is fond of the berries of the *toromiro* and also those of the *Gaultheria* shrub, but does not much appreciate those of the *tawa.* The pigeon is fond of *tawa* berries, and is speared on *tawa* trees, not snared. Both *kaka* and *kereru* are taken on *hinau* trees, when eating the berries thereof. The *tutu* trees for *kaka,* or trees on which they are taken with the *mutu* or perch and snare loop, are the *rimu, tawa, toromiro, hinau, kahikatea, maire, tawai,* and such *rata* as are clinging to *rimu* trees, but not such *rata* as stand alone.

During the *rarangi tahi* season of 1909 many *kaka* were taken by the ancient methods at Maunga-pohatu, by the followers of Rua the Keka.

In reference to the *whakawiri kaka*, already described, we note in White's Selborne a similar method employed to take daws, for which see Letter No. 21.

The term *rarangitahi* applies to the *rata* tree only. The *wai kaihua* or nectar is the only bird-food provided by the *rata*. Only the *kaka* were taken on the *rata* during the *rarangitahi*—taken with the spear—for only this bird is fat at such time; other birds are thin, for this is summer-time. All *rata* trees are not *kaihua*, because for some reason birds do not frequent all trees of that species. At the time of the *rarangitahi* the pigeon is on the *maire*, or eating leaves of the *wharangi*, *houhi*, *kowhai*, *hangehange*, &c., and is very thin. Hence it is not taken. It also eats the fruit of the *kotukutuku*. The pigeon is never taken by the striking (*hauhau*) method. It was both speared and snared on the *toromiro* tree when the fruit thereof was ripe.

The *tahei* process of snaring was employed on *matai*, *toromiro*, *maire*, and *kahikatea* trees, but not on *rimu* or *rata*. *Wai tahei* are streams and pools at which bird-snares are set. The term *rakau tipapa* is applied, says Paitini, to the *toromiro* tree only—to such as are much resorted to by pigeons, and on which they are snared. The loop snare is attached to, suspended from, a cord termed *takeke* or *tarawa*. In the *tahei* method the fowler ascends to the head of a tree and clambers out on the branches so far as they will bear his weight, and arranges his snares as far out as he can toward the outer ends of the branches. This method is employed on trees when the fruit thereof is ripe; hence such fruit acts as a *poa*, or bait. In flitting about to get at the berries, the birds are caught in the loop snares (*mahanga*). A bird that confines itself to the very outer extremities of branches, fluttering about or alighting on the foliage and not on the branches, is termed a *manu kai popoki*. To take such birds the *tarahanga* method is employed. The fowler arranges snares on a pole, which he thrusts outwards until the snares on it are outside or among the outermost foliage. A light lashing secures the pole to a branch. (*Mehemea ka kore e taea a waho, ka tarahanga, ara mo nga manu kai popoki.*)

The *hiwi ariki*, used in the *mutu* or *tutu* method, is not a pole *hiwi* permanently lashed to a branch, as are other *hiwi*, but is a branch of the tree on which the *kokirikiri*, with its attached *mutu*, is suspended. Birds taken in summer-time were often buried by fowlers until they returned home, in order to keep the flies from them. They were carried in baskets. As a rule a Native plucks the longer feathers of a bird as soon as it is taken, plucking being easier while the bird is warm. Such feathers were concealed, not left to be blown about, or birds would desert that forest. The long feathers only of both wings are termed *kira*, but the expression seems to be applied to the larger birds only. The down or minute feathers, termed *awe* and *nehu*, is left on in plucking. It is said to retain the fat well when potting the birds.

The act of counting birds, in braces, when prepared for preserving, is termed *whakamoe*. A person will say, "*Tena! Whakamoetia iho te manu nei.*"

The *makoi*, or barbed points for bird-spears, that were made of human bone, were made from the thigh-bones.

The *pewa* was really used for the *tihe* only, but the *tieke*, *rearea*, and *kokako* were occasionally taken on it. Berries of the *karamu* and *patate* were used as *poa* (bait) for the *pewa*, while the *pepe*, or call-leaf, was also employed to lure birds to this snare-mounted perch.

The *kokako* or crow has reappeared of late at Rua-tahuna. It is also seen in the Waioeka district, and on the ranges near Opouriao.

The word *karawa* denotes the female parent of birds and animals. The term *punua*, says Paitini, is applied to young birds after they commence to fly. *Pitaketake* is applied not only to chicks, young birds, but also to young pigs.

Pitongatonga is a name of the *pihipihi* bird.

There is more ritual pertaining to Tane than to any other god of the Tuhoean pantheon, not even excepting the dread, all-powerful Tu. For Tane was omnipotent in his realm, the forest; and who knows but that he is TAN, the cloud-bird, a high god of the old-time sojourners on the shores of the Indian Ocean!

Here endeth the lore of the Whare Mata—or, rather, such fragments thereof as we have collected in the forests of Tuhoeland; collected during many long tramps over forest ranges, by many camp-fires, within the primitive dwellings of the Child of Tamatea and the tents of an alien people; collected from those who followed the ancient art of the fowler in the days of their youth, from those who knew the forest as no white man knows it.

ART. LIII.—*Classification of Verse.*

By JOHANNES C. ANDERSEN.

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THE STRESS-UNIT.

Section I.

1. THE "stress-unit" is the smallest regularly recurring period or unit in a verse of poetry, the name being here used instead of the usual name "foot." The unit may be altogether silent, or it may contain from one to four or even five syllables, the last syllable bearing the stress when stress is present.

2. As it is commonly held that the stress may fall on any syllable of a unit, the following remarks are offered as reasons for suggesting that it always normally falls on the last; further, that all apparent varieties of units are closely allied, and spring from a common source. It will be attempted to show that all units may be resolved to the two-syllabled unit, commonly called the "iamb," which unit is capable naturally of expansion to the three-syllabled and four-syllabled units. As the stress is held to fall always on the last syllable of a unit, a unit will vary only in having less or more syllables; and for convenience a two-syllabled unit will be called a "duple unit," a three-syllabled a "triple unit," and a four-syllabled a "quadruple unit."

3. As mention of the various "feet" must be made during the discussion, the symbols and names are here given, the sign ⏑ representing an unaccented syllable, and — an accented, or stressed.

⏑ ⏑	Pyrrhic.	⏑ ⏑ —	Anapest.
— —	Spondee.	⏑ — ⏑	Amphibrach.
⏑ —	Iamb.	— ⏑ ⏑	Dactyl.
— ⏑	Trochee.	— ⏑ ⏑ —	Choriamb.

It is wished to show that all these feet may be traced to one fundamental duple unit, with its natural triple and quadruple expansions, such expansion being an innate quality.

4. The pyrrhic and spondee are admitted by prosodists to be feet of only occasional occurrence in British poetry: they are "variations," and not "fundamentals," and never of themselves form a metrical scheme, occurring only as isolated feet, due to the dropping or insertion of a stress.

5. The iamb and trochee, however, are fundamental feet that is, in aggregation either one may form a metrical scheme; but whereas the resulting measures were at one time considered quite distinct, there are now few prosodists who maintain that there is any real difference between them: the *lilt* of the measures is due rather to the syntactic than to the rhythmic construction. Their indiscriminate mingling in much of the best poetry is in itself sufficient to suggest their identity; and this identity may be made apparent by a few examples. The following pairs are from Milton's "L'Allegro." They are not consecutive lines in the poem, but are chosen on account of their internal construction being similar:—

(1.) *a.* Haste thee, Nymph, and bring with thee (l. 25.)
b. So buxom, blithe, and debonair. (l. 24.)
(2.) *a.* Some time walking, not unseen, (l. 57.)
b. With store of ladies, whose bright eyes (l. 121.)
(3.) *a.* Shallow brooks, and rivers wide; (l. 76.)
b. By hedge-row elms, on hillocks green, (l. 58.)

The only difference between the two lines of each pair is that the first begins with a stressed, the second with an unstressed, syllable; the internal pauses fall in the same manner, and drop the unstressed syllable opening *b* of each pair, and the lines of each pair are rhythmically identical. In the following examples the lines of each pair are consecutive:—

(4.) Mountains, on whose barren breast (l. 73.)
The labouring clouds do often rest;
(5.) Where perhaps some Beauty lies, (l. 79.)
The Cynosure of neighbouring eyes.
(6.) Sometimes with secure delight (l. 91.)
The upland hamlets will invite,
(7.) There let Hymen oft appear, (l. 125.)
In saffron robe, with taper clear.

In these four examples a trochaic line, or line stressed on the first syllable, is followed, *with no break in the metre*, by an iambic line, or line stressed on the second syllable; and the arbitrariness of this nomenclature is most apparent when it is pointed out that each of the couplets is no more than one long verse bisected. Quotations (6) and (7) should stand,

(6*a*.) Sometimes with secure delight the upland hamlets will invite,
(7*a*.) There let Hymen oft appear, in saffron robe, with taper clear.

The absurdity of giving the two halves of one verse different names, and holding that they are in different measures, is surely evident. They are in the same measure from start to finish; and the only question is, which measure is it to be, trochaic or iambic?

6. Take other examples, where the order of the last four is reversed—that is, where a trochaic line follows an iambic:—

(8.) And young and old come forth to play (l. 97.)
On a sun-shine holy day,
(9.) Oft listening how the hounds and horn (l. 53.)
Cheerly rouse the slumbering morn.

These in the full verse would stand,—

(8*a*.) And young and old come forth to play   on a sun-shine holy day,
(9*a*.) Oft listening how the hounds and horn   cheerly rouse the slumbering morn.

A distinct pause breaks the verse into two halves, and such pause is not so much syntactic as rhythmic: it takes the place of a syllable which is required to complete the metre. This pause gives the clue for the recognition of iambic metre in that which appears to be trochaic: the pause is evident in every instance where a trochaic line follows a stressed syllable, as in examples (8) and (9). It disappears when the line preceding has a double, or, as it is more commonly called, a "feminine" ending, as in the following:

(10.) And at my window bid good morrow   (l. 46.)
Through the sweet-briar, or the vine,

Here the light syntactic pause after "morrow" is quite different from the heavy rhythmic pause after "play" and "horn" in examples (8) and (9): the rhythmic pause has, in fact, been filled by the last syllable of "morrow."

7. The pause cannot, of course, be detected at the beginning of a poem whose opening is trochaic, but its presence in all subsequent places where a trochaic line follows a stressed syllable is indubitable evidence in favour of its presence at the opening also. It may occur in other parts of the verse than the beginning, as in Shakspeare's—

(11.) Thou for whom   Jove would swear   (On a day . . . l. 17.)
Juno but an Ethiop were.

It is evident that a pause equal to a syllable separates "whom" and "Jove": is it not equally evident that a pause equal to a syllable separates "swear" and "Juno"?

8. The fact that the ear is conscious of a *trochaic effect* in many verses is by no means disputed; but it is contended that it is not the rhythm or the metre which causes this effect, but the construction of the words themselves. Again quoting from "L'Allegro":—

(12.) Shallow brooks, and rivers wide;
(13.) Mountains, on whose barren breast

The words "shallow," "rivers," "mountains," and "barren" are themselves trochaic, or are accented on the first syllable, and not on the second, and they impress their own character upon the rhythm in which they float; for that rhythm, be it remembered, is itself inaudible. In "Il Penseroso," however, the following lines occur—

(14.) With antique pillars massy proof,   (l. 158.)
And storied windows richly dight,

—where six words out of ten are trochaic, yet they occur in iambic lines. The trochaic effect is still more noticeable when the lines have feminine endings, as in,

(15.) Straight mine eye hath caught new pleasures,
Whilst the landscape round it measures;
Russet lawns and fallows gray,
Where the nibbling flocks do stray;   (L'All., l. 69, &c.)

The feminine endings give the perfect form to the trochaic measure, and it will be noticed how great is the change when the feminine endings cease. It will also be noticed how the first and second lines are run together with absolutely no pause dividing them; and how the slight syntactic pause after "measures" is widened to the absolute rhythmic pause after "gray." Yet, though feminine endings make the perfect trochaic measure, such endings also occur in admitted iambic measure :—

(16.) With wanton heed and giddy cunning; (l. 141)
The melting voice through mazes running,
Untwisting all the charms that tie
The hidden soul of harmony;

A quite different effect results from the feminine endings in this example. Comparing (15) and (16), we have,

(15*a*.) Straight mine eye hath caught new pleasures, whilst the landscape round it measures;

(16*a*.) With wanton heed and giddy cunning: the melting voice through mazes running,

Example (15*a*) reads quite smoothly; (16*a*) has a curious "catch" in the middle, a "tripping" effect which is altogether absent from (15*a*). In fact, the endings "cunning" and "running" in example (16) are truly feminine, *each introducing a triple unit* into the verses: the endings "pleasures" and "measures" in (15) are only apparently feminine; no triple units result, as the extra syllables of the feminines merely take the places of syllables dropped from the trochaic openings.

9. Since they produce a triple unit, the last syllables of "cunning" and "running" would by many prosodists even of the present day be called hypermetrical or extra-metrical; but they are surely as much part of the metre as extra syllables introduced in any other part of the verse, as,—

(17.) Of herbs and other country messes, which *the neat-handed* Phillis dresses; (l. 85.)

Presumably "the" would be considered the extra-metrical syllable, for the verse runs smoothly without it :—

(17*a*.) Of herbs and other country messes, which neat-handed Phillis dresses;

The fact is, however, that these so-called extra-metrical syllables occupy slight syntactic pauses. These pauses will receive fuller attention in a subsequent section, and they need not receive further consideration at this point, it being noted that it is their presence after certain words arranged in syntactic groups that gives the iambic or trochaic *effect*.

10. In "L'Allegro" and "Il Penseroso" the trochaic and iambic lines can be readily perceived; but unless absolute indication is afforded by the rimes, or by some index other than the words themselves, it is often impossible to say of many poems if they are to be regarded as iambic or trochaic. Often it goes by majority: if over half the lines begin with trochees, the poem is considered trochaic; if over half with iambs, iambic: it has even been contended that the former gives a merry, the latter a more solemn, measure; and by these two arbitrary distinctions "L'Allegro" has been called trochaic and "Il Penseroso" iambic. Led by the rimes, a first reading of the following "Bacchanalian Verse" by Herrick will probably be iambic :—

(18.) Drink up
Your cup,
But not spill wine;
For if you
Do
'Tis an ill signe;

That we
Foresee,
You are cloy'd here,
If so, no
Hoe,
But avoid here.

This can be read, and the rimes would indicate that it should be read, as iambic verse; and it is not until the last line is reached that the reader can be certain the lines should be read not in iambic, but in trochaic measure.

11. Seeing, then, the absolutely interchangeable nature of these measures in poems like Milton's "L'Allegro" and "Il Penseroso"—remembering, too, the important fact that when a trochaic line follows one ending with a stressed syllable it is always divided from that syllable by an undoubted pause, and that when this pause, as is often the case, is filled with the syllable of a feminine ending the two lines run on as one—it appears to be beyond doubt that the names "iambic" and "trochaic" have been applied to one and the same metre, whose *words* may have a peculiar lilt, such lilt being imparted to them by their syntactic construction, and not by the rhythm in which they float. It is due to a misdirected zeal that a false standard has been established requiring the syllabic form of poems to conform with one or other of two "ideals," iambic or trochaic. The standard is, however, cumbered with permitted licenses. For instance, trochaic measure, which in its perfect form should throughout run in the form of the first two lines of example (15), is allowed the license of dropping the last and unaccented syllable of each line—is licensed, in fact, to become iambic, a license of which it makes use most freely; again, iambic measure is allowed the license of dropping an occasional opening unaccented syllable is licensed, in other words, to become trochaic. What does this mean more than that the same metre is appearing now in one form, now in the other, according as the syntactic construction, which is the visible and audible index, may direct?

Section II.

1. The two fundamental "two-syllabled feet" having been reduced to one simple unit with its stress on the second syllable, the three "three-syllabled feet"- viz., *anapest*, *amphibrach*, and *dactyl*—may now be taken into consideration.

2. The first three lines of the lyric opening Byron's "The Bride of Abydos" have been quoted by prosodists as examples of the three three-syllabled metres resulting from the use of anapestic, amphibrachic, and dactylic feet respectively:—

(1.) Knòw ye the/ lànd where the/ cỳpress and/ mỳrtle
Are èmblems/ of dèeds that/ are dòne in/ their clìme,
Where the ràge/ of the vùl/ture, the lòve/ of the tùr/tle,
[Now mèlt in/to sòrrow/ now màdden/ to crìme ?]

Taking each line as an entity, and numbering off from the beginning, the lines have been split into three-syllabled units, or feet, the first line containing dactyls, or feet stressed on the first syllable; the second line amphibrachs, or feet stressed on the second syllable; the third line anapests, or feet stressed on the third syllable. The fourth line is of the same construction as the second. It will be noted that each line tails off with a mutilated foot. Edgar Allan Poe was the first to point out the fallacy of the above division. He showed that the lines, though dividing in this mutilated way *to the eye*, flowed on unbrokenly *to the ear* when read aloud. In fact, the ear suggested a different division; and were it not for the syntactic construction it would be impossible to say where one metre ended and the other began.

3. As in the case of duple metre discussed in Section I, each line as printed in example (1) of this section is only a half-verse; the lines may

therefore be printed as full verses, still divided in feet of three syllables, starting from the beginning of each verse.

(1*a*.) Knòw ye the/ lànd where the/ cy̆press and/ my̆rtle are emblems of dèeds
that are/ dòne in their clime.
Where the ràge/ of the vùl/ture, the lòve/ of the tùr/tle, now mèlt/ into
sòr/row now màd/den to crìme ?

By this division the two verses read quite smoothly, and there is only one faulty foot in the two viz., the last foot of the first verse, which contains but one syllable stressed. Note, however, that were the two verses considered as one metrical entity, and the division continued as from the beginning, the whole would be composed of dactylic feet, instead of, as at present, half being dactylic and half anapestic. The second verse, however, would end with a defective foot, a single stressed syllable. The entity, then, containing two complete verses, or four lines, reads with perfect rhythmic swing throughout, and opens and closes with stressed syllables. Cannot an inference be drawn from an analogous example in duple metre ?—

(2.) Thère let/ Hy̆men/ òft a/ppèar, in/ sàffron/ ròbe, with/ tàper/ clèar,
And pòmp/, and fèast/, and rè/velry̆/, with màsk/, and àn/tique pà/geantry̆/;

Here also are two verses, or four lines, in perfect rhythm, opening and closing with stressed syllables; in two metres as divided, but only in one in reality—iambic. Example (2) should, then, be divided,

(2*a*.) Thère/ let Hy̆/men òft/ appèar/, in sàf/fron ròbe/, with tà/per clèar/,
And pòmp/, and fèast/, and rè/velry̆/, with màsk/, and àn/tique pà/geantry̆/:

Now, it has been shown that though a verse may open with a stressed syllable in duple metre, that metre is still iambic, the first unit being composed of a stressed syllable preceded by a pause. Example (1*a*) is no more than the triple equivalent of (2*a*), which implies, also, that the dactylic foot is simply the reverse of the anapestic foot, the shadowy amphibrachic foot being nothing more than the intermediary. This may be put in the language of signs thus :—

Anapest.	Amphibrach.	Dactyl.
⏑ ⏑ —	⏑ — ⏑	— ⏑ ⏑

The contention, then, as regards Byron's lines is that their division should be in units stressed on the third syllable, thus :

(3.) Knòw/ ye the lànd/ where the cy̆/press and my̆r/tle are èm/blems of dèeds/
that are dòne/ in their clime/,
Where the ràge/ of the vùl/ture, the lòve/ of the tùr/tle, now mèlt/ into sor/-
row now màd/den to crìme ?/

4. Examples, almost pure, of the three supposed triple metres may, of course, be found, and one of each is quoted :—

(4.) *Dactylic.*

Bird of the wilderness,
Blithesome and cumberless,
Light be thy matin o'er woodland and lea !
Emblem of happiness !
Blest is thy dwelling-place !
Oh, to abide in the desert with thee !

(*Hogg*, "The Skylark.")

(5.) *Amphibrachic.*

The gay birds are singing,
The gay flowrets springing,
O'er meadow and mountain and down in the vale :
The green leaves are bursting ;
My spirit is thirsting
To bask in the sunbeams, and drink the fresh gale.

(*Barton*, "Spring.")

(6.) *Anapestic.*

The Assyrian came down like a wolf on the fold,
And his cohorts were gleaming in purple and gold,
And the sheen of his spears was like stars on the sea,
When the blue wave rolls nightly on deep Galilee.
(*Byron*, "The Destruction of Sennacherib.")

The third example only is perfect; (4) to be perfect should have the words "lea" and "thee" each followed by two unaccented syllables, and (5) to be perfect should have the words "vale" and "gale" each followed by one unaccented syllable. In all three examples each full verse ends on a stressed syllable; and dividing a verse of each, not in accordance with its supposed metre, but in accordance with (3) above, we have,—

(4*a*.) Bìrd/ of the wil/derness, blìthe/some and cùm/berless, lìght/ be thy mà/tin o'er wòod/land and leà !/

(5*a*.) The gày/ birds are sìng/ing, the gày/ flowrets sprìng/ing o'er mèa/dow and moùn/tain and dòwn/in the vàle/.

(6*a*.) The Assỳ/rian came dòwn/ like a wòlf/ on the fòld/, and his cò/horts were gleà/ming in pùr/ple and gòld/.

Each verse is now identical in all but the first unit; and in examples (4) and (5) it will be noticed that there is a metrical pause after "lea" and "vale," such pause representing in the case of (4) two dropped syllables, and in the case of (5) one dropped syllable. It appears probable, then, that examples (4), (5), and (6) are in reality in the same metre—anapestic; an important fact to remember being that whilst a poem in anapests almost invariably ends on a stressed syllable, it very rarely opens with two unaccented syllables – in the great majority of cases it opens with one, and sometimes with the stressed syllable, as in such poems as (4) and (5) and the following:—

(7.) My heart's in the Highlands, my heart is not here,
My heart's in the Highlands a-chasing the deer.
(*Burns*, "My Heart's in the Highlands.")

(8.) Hie upon Hielands
And low upon Tay,
Bonnie George Campbell
Rode out on a day.
(*Anon.*, "Bonnie George Campbell.")

5. In their absolutely perfect form, poems in dactylic and amphibrachic measures are not so frequently met with: examples are:—

(9.) *Dactylic.*

Tell me, thou bonny bird,
When shall I marry me?
When six braw gentlemen
Kirkward shall carry ye.
(*Scott*, "Proud Maisie.")

(10.) *Amphibrachic.*

And do I then wonder that Julia deceives me,
When surely there's nothing in nature more common?
She vows to be true, and, while vowing, she leaves me—
But could I expect any more from a woman?
(*Moore*, "Inconstancy.")

The very rarity of such perfect forms shows that, whilst they exist, they are unnatural.

6. Objection may be made that by the proposed anapestic division of Hogg's verses the words "wilderness," "blithesome," "cumberless," "matin," &c., are divided, part being in one unit and part in another; whereas in a dactylic division the whole of each of these words falls within the unit. This objection has already been met in paragraph 8 of

Section I: it is the words themselves that are dactylic, not the rhythm: and to divide according to the word-construction is syntactic, not rhythmic, division. Take a poem where this dactylic effect, produced, as before noted, by the almost impalpable syntactic pauses dividing words, is most strongly marked Hood's "Bridge of Sighs":

(11.) Make no deep scrutiny
Into her mutiny
Rash and undutiful:
Past all dishonour
Death has left on her
Only the beautiful.

The "effect" here is undoubtedly dactylic; but Hood could only maintain the perfect measure in short snatches, heightening the effect by the free use of dactylic words or words of three syllables accented on the first syllable—as, "tenderly," "slenderly," "humanly," "womanly," "dutiful," "beautiful," &c. But other effects are evident:

(12.) The bleak wind of March
Made her tremble and shiver:
But not the dark arch
Of the black flowing river.

Here anapests and amphibrachs take the place of dactyls. Amphibrachs preponderate in -

(13.) *a.* So far in the river.
b. From window and casement,
From garret to basement,
She stood, with amazement &c.

Anapests in -

(14.) *a.* Young, and so fair!
b. Swift to be hurled -&c.

The examples in (14) are paralleled by Thackeray's "Mahogany Tree," which is in anapests. (See example (61) in Section III.)

7. The difficulty of maintaining a dactylic metre that shall be perfect in form for any length of time is shown by the continual lapses in such metre. The "Bridge of Sighs" evidences this, and still more does Scott's song,—

(15.) Where shall the lover rest,
Whom the fates sever
From his true maiden's breast,
Parted for ever?
Where, through groves deep and high,
Sounds the far billow,
Where early violets die
Under the willow.

Not only are the units "lover rest," "maiden's breast," "deep and high," "violets die," very poor dactyls, the necessarily unaccented syllables being much too heavy, but the riming is most faulty. The rime should begin on the stress and ring through the unaccented syllables, as in "slenderly" and "tenderly"; here it does not appear until the last syllable, which is unaccented. In the third stanza—

(16.) Where shall the traitor rest,
He the deceiver,
Who could win the maiden's breast,
Ruin and leave her?
In the lost battle,
Borne down by the flying,
Where mingles war's rattle
With groans of the dying,

—the metre breaks down; it becomes amphibrachic, intermediate between dactylic and anapestic.

8. As in Byron's lyric, so in Moore's "Sound the Loud Timbrel," the three metres are mixed:-

(17.) Praise to the Conqueror, praise to the Lord!
His word was our arrow, His breath was our sword.
Who shall return to tell Egypt the story
Of those she sent forth in the hour of her pride?
For the Lord hath looked out from His pillar of glory,
And all her brave thousands are dash'd in the tide.
Sound the loud timbrel o'er Egypt's dark sea!
Jehovah hath triumphed; His people are free.

Here lines 3 to 6 are identical with quotation (1) in this section, so-called dactyl, amphibrach and anapest following one another and dovetailing perfectly.

9. Prosodists allow dactylic verse two licenses: the last two unaccented syllables may be dropped, so that the verse ends on a stress, and it may be preceded by an unaccented syllable. By the examples from Byron and Moore, (1) and (17), it will be seen that it may also be preceded by *two* unaccented syllables. What results? By allowing the dactylic verse these licenses it is allowed to become an anapestic verse—a consummation towards which it is perpetually struggling. The conclusion then appears inevitable: The ending on a stressed syllable, and the prefixing of unaccented syllables, are not so much licenses as assertions of the natural type: the metre is doing its utmost to revert - a constantly recurring act in all artificial forms throughout living nature. In the quotation above (17) it will be observed that after each of the first two lines there is a pause, as also after the sixth and seventh. These pauses take the places of syllables that have been dropped; the syllables are present in the third to fifth lines, hence their unbroken swing. Restore the syllables throughout, and what is the result? Either the whole stanza is in dactyls minus the last two unaccented syllables, or in anapests minus the first two, or in amphibrachs minus the first and the last. Is it not, then, supererogative to give three names to what is practically the same metre?—and for the same reason that all duple metre is more naturally iambic than trochaic, all triple metre is more naturally anapestic than either amphibrachic or dactylic.

Section III.

1. Having offered reasons for reducing the number of constituent units of British metre to two normal basic units, two-syllabled and three-syllabled, or duple and triple, it remains to consider the relationship of these two each to the other. It has been maintained that each has its own peculiar "effect"; that the "time" of duple metre differs from the "time" of triple metre in the same manner that march-time differs from waltz-time; that the two do not naturally mingle in one metrical scheme, but that where they do occur together the triple unit becomes a "triplet," of a nature different from the triple unit when it occurs unmixed with the duple.

2. In any poem that may be examined some lines will appear syllabically fuller than others. Quoting again from "L'Allegro," the line,

(1.) And fresh-blown roses wash'd in dew.

is fuller than the line,

(2.) To live with her, and live with thee

There is less pause between the units of the first line than between the units of the second, because in the former case there is more articulate sound in the units, they being much more heavily charged with consonants. In the second line there appears a distinct though undefinable pause, or, rather, a sustaining of the voice, after each unit:

(2*a*.) To live with her, and live with thee

Each unit is occupied by something more than the words a space which in the first line is almost entirely occupied by the consonantal sounds of "fresh," "roses," and "wash'd." When the unit has a naturally long vowel in the stressed place the pause is perhaps not so apparent, as such vowel is instinctively dwelt on; so, too, when the stressed vowel is followed by a liquid, upon which the voice finds no difficulty in dwelling. The reality of this "vocal pause" is more apparent when syllables are inserted to take its place, as in the following lines from "L'Allegro": -

(3.) The la/*bouring clouds*/ do of/ten rest/. (l. 74.)
(4.) Are at/ their sa/*voury din*/ner set/. (l. 84.)
(5.) The clouds/ in thou/sand li/*veries dight*/. (l. 62.)
(6.) To ma/*ny a youth*/ and ma/*ny a maid*/. (l. 95.)

In each italicised unit the pause has been filled by an extra syllable, and the effect produced is unmistakable. The pause can be restored by writing and pronouncing "labouring" "lab'ring," "savoury" "sav'ry," "liveries" "liv'ries," and by eliding or coalescing the vowels "y" and "a" in "many a"—"many'a"; and it will be remembered how common such mutilated forms are in verse printed according to the older rigid artificial school of poetry, whose inflexible rule was that in duple metre no unit could contain more than two syllables. When such mutilations are indulged in, it will be noted that the restored pause, whilst it follows the unit, divides the word.

3. The pause is made more apparent by the presence of triple units:—

(7.) As blithe as the linnet sings in the green wood,
So blithe we'll wake the morn;
And through the wide forest of merry Sherwood,
We'll wind the bugle horn.
(Ballad-farce, "Robin Hood," 1751.)

Here the palpable pauses in the second and fourth lines seem to call for syllables, and the call is answered and satisfied by saying,-

(7*a*.) As blithe as the linnet sings in the green wood,
So blithely we'll waken the morn;
And through the wide forest of merry Sherwood,
We'll blow on the echoing horn.

This, it may be held, is an undoubted proof that the metre in this instance is triple, not duple, and is so indicated by the opening line, even though in the whole stanza there are only six triple against eight duple units. There are poems, however, in which the duple and triple units blend so perfectly that the contrast is not so pronounced as in (7). Take, for example, "The Fairy's Song," by J. H. Dixon:—

(8.) When the village is wrapt in quiet sleep,
And the hum of voices is still,
From our tiny mansions we softly creep,
And hie to the thymy hill.

And there we trip with our nimble feet,
While the moonbeams fall on the fell,
And our melody is the music sweet
That peals from the heather-bell.

Here the first stanza contains seven each of duple and triple units; the second contains six triple and eight duple: what is the resultant metre? The fact is, it is impossible to say where duple metre ends and triple begins. This is notably so in many of the older ballads; for example, "The Lochmaben Harper," "Jock o' the Tyde," "Hobbie Noble," "Kinmont Willie"—all from Scott's "Border Minstrelsy." On the rise of the artificial school of prosody all such "mixed" verse was considered not only faulty, but vulgar, and was left to the mercies of the uneducated; and their mercies certainly proved tender, for to them we owe the preservation of our immortal ballads. The artificial school held that all units should be uniform—that in a verse all should contain either two or three syllables. Furthermore, it was considered impossible to rise to poetic heights in three-syllabled metres, so that metre fell into disrepute. Dryden and Pope, the chief exponents of the artificial school, confined themselves almost entirely to the two-syllabled metre. Dryden, according to Samuel Johnson, carried to more perfect pitch the reform in English verse begun by Waller and Denham. The following extract is from his Life of Dryden: "After about half a century of forced thoughts, and rugged metre, some advances towards nature and harmony had been already made by Waller and Denham; they had shown that long discourses in rhyme grew more pleasing when they were broken into couplets, and that verse consisted not only in the number, but in the arrangement of syllables." So important was the *number* of syllables considered, that to write in verse was to write in numbers: Pope, in whom the artificial style culminated, "Lisped in numbers, for the numbers came." It is due to the fact that we have not yet cast off this yoke of "number" that we look askance at a mingling of duple and triple metres; yet can we find fault with poems like Coleridge's "Christabel" or Shelley's "Sensitive Plant"?

4. Cowper, master of the anapest, was the first to revive the three-syllabled metre; and whilst he did not, perhaps, intentionally mingle the two-syllabled and three-syllabled, from two of his finest examples of the anapest, "The Rose" and "The Poplar Field," the following lines are taken:—

(9.) The rose had been wash'd, just wash'd in a shower,
(10.) The poplars are fell'd; farewell to the shade

The poems of which these two are the opening lines are admittedly anapestic; yet a line of exactly similar construction—

(11.) And over his chere is sobre and softe,
(C.A., Book I, "Pride," l. 45.)

- is iambic. It occurs in Gower's "Confessio Amantis." How can a metre of identical construction bear one name in one context, another in another? It may be held that we do not know how such a line would be read in Gower's time. It is not necessary to know this; the question is, how is it read now? If it is read like Cowper's lines, is it not the same metre? The anomaly disappears if it is admitted that two-syllabled and three-syllabled (duple and triple) metres are interchangeable—are, indeed, two manifestations of the same unit. Then Gower's lines,

(12.) Out of the temple he goth his way.
And she began to bid and pray,
(C.A., Book I, "Pride," l. 359.)

and (11) above offer no stumbling-block to scansion: the unit has protean powers, and these are the powers contributing towards the endless variations in which it is capable of appearing. Thus it is that the following lines from "Thomas the Rhymer" are congruous and harmonious :

(13.) Alas, he seyd, ful wo is me,
I trow my dedes will werke me care,
Jesu, my sole tak to ye,
Whedir so euyr my body sal fare.
(Appendix to "Thomas the Rhymer," Scott's Minstrelsy.)

5. Mr. T. S. Omond, in his "Study of Metre" (p. 51), quotes the following verse—

(14.) The sun, the moon, the stars, the seas, the hills

—and says concerning it, "No one, reading it, would doubt its iambic structure . . . Yet, if we turn to Tennyson's poem 'The Higher Pantheism,' we shall find the words in the first line, followed by other three: 'and the plains.' This addition works a notable change . . . the time underlying the whole poem is triple." If this be so, then surely the time underlying all duple verse may be considered as triple, for all duple units have the latent power of amplification to triple; and in this light the identification of British with classic iambs may not, after all, be altogether erroneous. But, employing similar argument as with Tennyson's verse, should not Shelley's "Indian Serenade" be in triple time? for we find in almost every line a triple unit in the most important position, the opening

(15.) *I arise* from dreams of thee
In the first sweet sleep of night,
When the winds are breathing low,
And the stars are shining bright.

—yet who will hold that this poem is in triple rather than in duple time? If, again, quotation (14) is in triple time simply because it is followed by a triple unit, what is to be said of Milton's verse?—

(16.) And swims, or sinks, or wades, or creeps, or flies :
(P.L., ii, 950.)

This verse, from "Paradise Lost," is undoubtedly duple. If, then, Tennyson's verse is triple, though exactly similar in construction, is that fact not a proof of the triple potentiality of duple verse? Take the opening of a Song, by Miss Bryant :—

(17.) Ah! friend beloved, in the cold earth fading,
By every fragile mind forgot ;

A first reading would make this duple:—

(17*a*.) Ah! friend/ belò/ved in/ the còld/ earth fà/ding,
By è/very frà/gile mind/ forgòt/ ;

but on the addition of the following verse quite another grouping of the syllables starts up :—

(17*b*.) Ah! friend beloved in the cold earth fading,
By every fragile mind forgot ;
Like a drooping tree a dead flow'ret shading,
My form still bends o'er thy resting spot.

The metre has become triple. Again, take Drayton's "Battle of Agincourt" :—

(18.) Fair stood the wind for France,
When we our sails advance,
Nor now to prove our chance
Longer will tarry,
But putting to the main
At Kaux the mouth of Seine,
With all his martial train
Landed King Harry.

In the first line the words naturally accented are the second, fourth, and sixth; the same is true of the second and third lines. Naturally, then, the stanza will be read in iambics until the fourth line breaks the metre, and the eighth rouses a doubt as to what metre is really intended. The doubt is resolved when a stanza like the following is met :—

(18*a*.) Suffolk his axe did ply.
Beaumont and Willoughby
Bore them right doughtily,
  Ferrors and Fanhope.

The metre is intended for dactylic; and as such, rugged indeed, yet dactylic, it must be read.

6. A more curious example of the interchangeable nature of duple and triple is furnished by Lady Nairn's "Land o' the Leal." The first stanza is in perfect triple metre :—

(19.) I'm wearing awa', Jean,
Like snaw when it's thaw, Jean,
I'm wearing awa'
  To the land o' the leal.

(I'm wèar/ing awà'/, Jean, like snàw / when it's thàw/, Jean, I'm weàr/ing awà'/ to the lànd/ o' the lèal/.)

Yet take the last stanza : —

(19*a*.) Then dry that tearfu' e'e, Jean,
My soul langs to be free, Jean,
And angels wait on me
  To the land o' the leal.

Now the metre appears undoubtedly duple; and with this duple idea the first stanza is sung paused as follows :—

(19*b*.) I'm wear/ ing/ awa'/, Jean/,
Like snaw/ when/ it's thaw/, Joan/,
I'm wear/ ing/ awa'/ to/ the land/ o'/ the leal/.

7. The questions of "pause" and "time" go together. The "time" of a unit is the interval of time between stress and stress; and, whilst such intervals vary in a slight degree according to the emotion of the verse, in any one metrical scheme they are approximately equal. The greatest amount of variation is caused by the syllabification: a unit containing only one syllable would appear to be of shorter duration than one containing three; but the one-syllabled unit is compensated by pause, and both are practically equal, though there is always a tendency towards the shortening of a pause. Triple units appear to be in faster time than duple; but, if anything, they are in slower time. It is not so much, however, the time that varies, as the rate of articulation of the syllables spoken. Though the "time" of any two units is comparatively equal, if one has more syllables than the other it will appear to be faster. In ballad-metre, owing to the abstract emotion of the narrative form, the time-value of the units varies little, and it is this which gives the sing-song nature to that metre; in dramatic blank verse, on the other hand, where action makes the emotion actual, the time-value of the units varies constantly. This variation can be demonstrated by reading aloud; and, whilst the unaided ear cannot always detect the variations of time in progressive units, such variation is at once apparent when the reading is done to the beats of a metronome. In the fundamental rhythm of poetry, time-value is of primary importance; syllables are secondary, though the presence of syllables is necessary to indicate metre. The metrical units float upon rhythmic units, accent and

stress usually coinciding; but the rhythm is still there, though the syllables be absent—hence the "pauses." It is for this reason, too, that once the time-value of the rhythm has been impressed on the imagination syllables may be dropped, and stresses suppressed, without danger of the rhythm being lost. More: there may even be occasional clash of accent and stress - that is, the syntactic accent may fall in places where there is no rhythmic stress, an unaccented, unimportant word clogging and muffling the stress. The result is momentary dissonance; and, as in music, it must be sparingly used, or the rhythmic harmony is destroyed.

8. The school of poetic "numbers" made syllables, not time, of primary importance. Many verses even of our first poets were by that school regarded as defective if they happened to contain less or more than the standard number of syllables supposed to go to a verse. In blank verse or heroics, for example, every verse was to contain ten syllables; certainly not less, and, if at all possible, not more. Procrustean drastic measures were adopted by the prosodists to compel recalcitrant verses to conform to this rule. That school also required that every unit of iambic verse should contain two syllables: the result to them was "smoothness of numbers"; to us, intolerable monotony. Pope's verses glitter artificially; they do not flash with life. The two verses from "Paradise Lost"—

(20.) To do ought good never will be our task,
But ever to do ill our sole delight, (P L., i, 159.)

—are animadverted upon by the commentator Newton in this way: "Dr. Bentley would read it thus:

(20*a*.) To do ought good *will never* be our task,

as of a smoother and stronger accent; but I conceive that Milton intended it to vary the accent of *never* and *ever* in the next verse." Bentley, then, would mend an irregular metre by changing the position of the words, and Newton would destroy a strong metre with a wrong accent. Smoothness and evenness are accentuated and relieved by occasional departures from the rigid type, and it is in the subtlety of variation caused by such departure that Milton excels. Neither of his commentators could appreciate the value of a pause other than that at the verse-end, and neither would admit a triple unit; but in this instance the irregular construction brought about by making the first syllable of "never," preceded by a pause, occupy a whole unit, a triple unit following, adds most decided emphasis to the text:

(20*b*) To do/ ought good/ nè/ver will bè/ our tàsk/.

This emphasis is entirely lost by both renderings of the commentators. The second verse, too, departs from the usual type there is a "clash of accent and stress":—

(21.) But ever to do ill our sole delight.

Here the syntactic accent should fall on "do," the rhythmic stress on "to." A compromise is necessary. Either the accent and stress should be made to coincide by introducing a triple unit followed by a paused unit, as,—

(21*a*.) But è/ver to dò/ ill/ our sòle/ delight/,

or accent and stress should be equalised, the words "to" and "do" being given equal weight, such weight probably, but not perhaps necessarily, to be less than that of the other stressed syllables of the verse—

(21*b*.) But è/ver to/ dò ìll/ our sòle/ delìght/

when again emphasis is given by a slight pause before "ill."

9. It is still held by some prosodists that poets at times deliberately give words a different accent from the prose accent. R. Bridges, quoting from Dr. A. Schmidt's "Shakespeare Lexicon," gives a very full list of examples in his Appendix on "Recession of Accent." From that list the following are taken:—

(22.) *a.* He is *complète* in feature and in mind (Gent., II, iv, 73.)
b. A maid of grace and *còmplete* majesty. (L L L., I, i, 137.)
c. Though time seem so *advèrse* and means unfit. (All's W., V, i, 26.)
d. Thy *àdverse* party is thy advocate. (Sonn., 35, 10.)

Here again is a clash of accent and stress, but the alternative scansions of (21*a*) and (21*b*) will not hold. Is there an actual recession of accent?—that is, has the accent absolutely been transferred from the second syllable to the first? Without doubt the first syllable bears the stress in the alternate examples of (22), but has the accent altogether disappeared from the second syllable? I think not. It will, I think, be found that (22) *b* will be spoken, not as—

(23.) A maid of gràce and complete majestỳ,

but as—

(24.) A maid of gràce and còmplète màjestỳ,

where the two syllables of "complete" receive almost equal prominence, the first by virtue of stress, the second by virtue of natural accent; the stress is, if anything, slightly heavier than the accent, but only slightly. It will be noted that most words with this alternative accent are two-syllabled words accented on the second syllable. This may be in accord with some philological law in the English tongue, where two-syllabled words accented on the first syllable greatly predominate over those accented on the second, in the proportion of at least three to one. This, too, may be the reason why, in poetry, two-syllabled words naturally accented on the first syllable seldom have the alternative accent on the second.

(25.) Nature hath framed strange fellows in her time:
Some that will evermore peep through their eyes,
And laugh like parrots at a bag-*piper*;
And others of such vinegar *aspèct*
That they'll not show their teeth in way of smile,
Though Nestor swear the jest be laughable.
(Merch. Ven., I, i, 51.)

Can a reason be assigned for the fact that two-syllabled words tend to take the accent on the first syllable? Words like "courage," "reason," "honour," "virtue," accented on the second syllable in Chaucer, now receive the accent on the first; the law in obedience to which this has resulted is still operative, for in Australia "miràge" is as often pronounced "mirage," and there, as elsewhere, does not the Scot say "rèsult" for "resùlt"? We have many instances, of course, where the two accents are used to give two different meanings, as "cònfines," "cònduct," "àbstract," "òbject," "sùbject," "rèbel," for the noun, and "confines," "condùct," "abstràct," "objèct," "subjèct," "rebèl," for the verb. These words could naturally not receive the alternate accents, as each accent has its own definite signification. Again, there are words which in the old ballads, as, too, in some modern compositions, received the alternative accents—such as "dàughter," "plàyer," "làdy," "còuntry," distorted into "daughtèr," "playèr," "ladyè," "countree" or even "counterie." It belongs perhaps to philology to explain many of these variations, but prosody must at least notice them.

10. Often the clash between stress and accent is avoided by judicious pausing: the pause need not even be equal to a syllable, but it serves the purpose of separating two elements that are at war if juxtaposed, but are in harmony when superimposed. In any unit a rhythmic stress will never, apparently, yield to a syntactic accent: if the latter be present, the former will not be absent: they may be coalesced by a pause, and harmony is restored. Over and over again verses occur where it is impossible to overlook the fact that a pause forms a vital part of the unit. The pauses in Tennyson's

(26.) Break, break, break,

cannot possibly be overlooked; and they are as evident in the second of Moore's lines,-

(27.) But there's no/thing half/ so sweet/ in life/
As love's/ young/ dream/.

Is it not evident that a syllable has been dropped before each of the words "young" and "dream," and that the place of such syllable is occupied by a pause? Each of the words "young" and "dream," with its auxiliary pause, forms a complete unit, equal in time-value to any other unit in the verse-- even to the first, which contains three syllables. That this is no fictitious value may be seen in the two following lines

(28.) *a.* Oh/, dear/, what/ can the mat/ter be,
b. March/, march/, Et/trick and Te/viotdale,

—where there can be no doubt that the units composed of a single syllable and pause are equal to those containing three syllables.

11. Always, then, when the unit contains only one syllable often when it contains two, and even when it contains three—a more or less palpable pause may be discerned. This pause is most evident when the units of the verse are not equally syllabled--that is, when one-syllabled and two-syllabled, or two- and three-, or one-, two-, and three-syllabled units mingle in the one verse.

(29.) The nè/vir a wòrd/ had Dì/ckie to sày/,
Sae he thrùst/ the lànce/ through his fàuse/ bodiè/.

This verse is from "Kinmont Willie," one of the old ballads that show the intimate mingling of duple and triple metres. In "Kinmont Willie" the duple predominates, yet in verses such as (29) it will be noticed that whenever a duple unit follows a triple a slight pause comes between: a pause, be it remembered, which is vocal; it is not a cessation of sound, but a dwelling on the stressed vowel. In the second line of (29) a pause —slight indeed, yet a pause--precedes "the lance," and another precedes "bodie." It is possible to change the position of the first of these pauses by making the stress fall on "through" instead of on "lance"

(29*a.*) Sae he thrùst/ the lance thròugh/ his faùse/ bodiè/.

—or it is possible to cause the disappearance of the pauses by putting syllables in their place—

(29*b.*) Sae he thrùst/ the long lànce/ through his crà/ven bodiè/.

12. It is not contended that the two-syllabled and three-syllabled metres cannot each have a distinctive "tempo"; but it is contended that such "tempo" is artificial, and, if it exist, is the result of the schools drawing a sharp line of demarcation between units containing two and units containing three syllables—it is, in fact, a result of the artificial science of

"numbers." Coleridge and Shelley, in "Christabel" and "The Sensitive Plant," are but reasserting the liberty that was enjoyed by the old balladists: they are restoring the form with an exalted spirit.

13. Again, it may be held that, admitting the pause on the stressed vowel, this pause is not due to the potentiality of the duple unit to expand to the triple, but to the fact that the stressed vowel is often a naturally long one, as in the last lines of Marvell's "Song of the Emigrants in the Bermudas"

(30.) And all the way to guide their chime,
With falling oars they kept the time.

—where every stressed vowel except that in "kept" is long, and would naturally be dwelt on. This very fact that every duple unit has apparently the power of lengthening its stressed syllable, and the fact that the stressed syllable is in many cases actually sustained as if to bridge over some slight gulf between it and the following syllable, have led to the conception of the idea that "quantity," as understood of classical verse, may be an integral part of English verse, or may be made so—that is, that there may be long and short syllables bearing some definite and constant relationship to each other. This is, in many cases, actually brought about when a poem is set to music, as in "Ye Banks and Braes," "Jockey to the Fair," "Love's Young Dream," and so on, where the stressed syllables are twice the length of the others; but there is absolutely no uniformity or consistency in this, and the three songs mentioned could just as well have been set to music such as that of "Jock o' Hazeldean," where each syllable, stressed or not, receives equal value, or that of "Macgregor's Gathering" and "Kitty of Coleraine," whose words are not duple but triple.

14. In Shakespeare and Milton, vowels which certainly are naturally short appear in stressed positions quite as often as vowels that are naturally long; short vowels being the *a*, *e*, *i*, *o*, *u* in "pat," "pet," "pit," "pot," and "put" or "nut," as against their long sounds in "mate," "mete," "mite," "mote" and "moot," or "mute." These are not intended to comprise all the vowel sounds, but merely to show the difference between naturally short and naturally long vowels. They appear with equal frequency in stressed positions, and both may be dwelt on or vocally paused. As noted in example (29), the pause preceding a duple unit disappears when that unit is made triple. There is perhaps not a poet who has resisted the temptation offered him of filling the pause with a syllable. Dryden has these verses in "The Hind and the Panther": -

(31.) *a.* We take *the unuse*ful scaffolding away. (l. 125.)
b. *Covering adultery with* a specious name: (l. 354.)
c. Burnish'd, and bat*tening on* their food, to show (l. 390.)
d. As long as words a dif*ferent sense* will bear, (l. 462.)
e. Forgive the slan*derous tongues* that call'd you so. (l. 594.)
f. If sight *by emis*sion or reception be, (l.)

Pope has these in "An Essay on Man":—

(32.) *a.* Some hap*pier is*land in the wa*tery waste*, (Pt. i, l. 106.)
b. How instinct varies in the *groveling swine*,
Compared, half-rea*soning ele*phant, with thine!
'Twixt that, and reason, what a nice *barrier?*
For ever se*parate*, *yet* for ever near! (*Ib.*, l. 221.)
c. Yet never pass *the insu*perable line! (*Ib.*, l. 228.)
d. On dif*ferent senses* dif*ferent ob*jects strike; (Pt. ii, l. 128.)

Examples like (31) *a* and (32) *e* are extremely common in both these strict writers of "numbers." The intruding syllable is avoided in reading by eliding the vowels -"th' unuseful," "th' insuperable"; in the other examples the vowel making the extra syllable is cut out "cov'ring," "batt'ning," "wat'ry," "grov'ling," &c.; in "by emission" the vowels "y" and "e" are read as one so far as possible, and the same with the "i" and "e" in "happier." In verse 3 of (32) *b* the "a" appears to be intrusive. The "numbers" are very evident in these authors: the syllables in their heroic couplets are never less than ten, and not often more. In the former respect they followed Milton: they out heroded him in the latter, slaughtering the vowels wherever possible; and the commentators marked their graves remorselessly with the sabre sign '. The fact to observe is, that whilst triple units were almost rigidly excluded from duple verse, the writers were conscious of a pause into which an extra syllable might be inserted without dislocation of rhythm.

15. The due observance of the time-value of units gives full effect to the subtle pause-melody of Christina Rossetti's poetry. What is the beautiful "Dream-love" without its pauses?

(33.) Yoùng/   Love/ lies slèe/ping   /
In Mày-/time   / of the yèar/.   [*or*, In Mày-/time of / the yèar/]
Amòng/   / the lì/lies   /
Làpped/ in the tèn/der light/ :
White/   làmbs/ come grà/zing,   /
White dòves/ come buil/ding thère/ :
And ròund/   / abòut,/ him   /
The Mày-/bùshès/ are white/.

In these pauses, which need not always exactly fill the place of the dropped syllables, and whose places will without doubt be varied by different readers, there is a sustaining of sound that bridges any break. Without observation of the pauses the verse becomes rugged and displeasing. The poetess herself must have experienced the enchantment of the vocal pauses when she says,—

(34.) Him perfect music
Doth hush unto his rest,
And through the pauses
The perfect silence calms
Oh, the poor voices
Of earth from east to west,
And poor earth's stillness
Between the stately palms.

Byron was incapable of music of this kind: his units almost always have their complete tale of syllables, and his metres are generally remarkably pure and obvious. This fact, making the reading of his verses technically easy, has probably helped in adding to his popularity. He himself says in a letter to Moore, "I am a man of all measures." He was freest in his triple measures, but altogether lacked the subtlety of pause and cunning variation. He, with Moore, could "sound the loud timbrel"; he could "tear a passion to tatters," but he seldom approached the "perfect peace" of Christina Rossetti's verse. Moore shows curious, but obvious, examples of the pause in "Love's Young Dream," and again in the following:—

(35.) While gazing on the moon's   light,
A moment from her smile I turned,
To look at orbs, that, more   bright,
In love and distant glory burned.
But *too*   far
Each proud   star,
For me to feel its warming glance:

The pauses of this stanza are filled with syllables in the following almost parallel stanza :—

(36.) The young May-moon is beaming, love,
The glow-worm's lamp is gleaming, love :
How sweet to rove
Through Morna's grove,
While the drowsy world is dreaming, love.

Burns employs similar pauses in—

(37.) John Anderson my jo, John.

These pauses are obvious ; and it will hardly be denied that the time-value of the units is the same whether they contain one or three syllables. (See paragraphs 2 and 3 of Section VI.)

16. The pause is neither so simple nor so obvious when it does not take the place of syllables ; yet it was probably this pause which led Herrick to break the Alexandrine verse,

(38.) Thus I passe by, and die : as One unknown, and gon :

into the Lilliputian stanza,

(39.) Thus I
Passe by,
And die :
As One
Unknown,
And gon :

The pauses after " die " and " gon " are considerably longer than those after the other stressed syllables, for they represent a dropped full unit.

17. Nor does the pause always fall evenly on or after the stressed syllables. In the line from " L'Allegro,"

(40.) But come, thou goddess fair and free, (l. 11.)

the second pause does not fall between the second and third units, but divides the third, appearing to make the second consist of the words " thou goddess," as—

(40*a*.) But come, thou goddess fair and free.

It was this irregular fall of the pause which led Bridges to formulate his system of stress-units. It has also led to certain syllables in a verse being called " extra-metrical " or " supernumerary." These syllables appear more frequently in blank verse. The following are from Book II of " Paradise Lost " : -

(41.) *a.* Retire, or taste thy fol*ly*, and learn by proof,
Hell-born, not to contend with spi*rits* of Heaven.
(lines 686, 687.)
b. Strange horror seize *thee*, and pangs unfelt before. (l. 703.)

It may be said that the syllables in italics are " supernumerary " owing to the presence of the pause ; but they were so considered when no account of pause was taken in the composition of units, for in older editions we find the verses printed,—

(41*a*.) *a.* Retire, or taste thy folly' ; and learn by proof,
b. Strange horror seize thee', and pangs unfelt before.

The apostrophe was an indication that the two vowels between which it appeared were to be coalesced, or the first of the two elided. Neither act could take place were they separated by a pause, and the only interpretation that can be given to this manner of printing is that the actual barbarity of elision was intended—that the unit was to contain only two syllables.

Newton, in his edition of Milton, praises this metrical variation as excellent in the poet; but adds, "But then these excellencies in Milton's verse are attended with this inconvenience, that his numbers seem embarras'd to such readers as know not, or know not readily, where such elision or abbreviation of vowels is to take place; and therefore for their sakes we shall take care throughout this edition to mark such vowels as are to be cut off, and such as are to be contracted and abbreviated, thus '."* Verses containing one clipped and one untouched triple unit, are, however, not uncommon:

(42.) *a.* to mitigate and swage
With solemn touches troubled thoughts, and chase
Anguish and doubt and fear and sorr'*ow and pain* (P.L., i, 558.)
From mortal or immortal minds.

b. But they
Drea*ded not more th' adven*ture than his voice (P.L., ii, 474.)
Forbidding: and at once with him they rose;

Innumerable verses containing a single unclipped triple unit could be quoted; the foregoing have been selected as containing one clipped and one untouched. Is there any difference between "anguish and doubt" and "sorrow and pain"? Surely both are identical in metrical structure. Take another verse:-

(43.) bears, tigers, ounces, pards,
Gambol'd before *them ; th' unwiel*dy elephant (P.L., iv, 345.)
To make them mirth us'd all his might,

Here the elision does not get rid even of the supernumerary syllable, for the unit contained four syllables in the first place, and still contains three. Again, take the following quotation from "Julius Caesar":

(44.) Brutus and Caesar: what should be in that Caesar?
Why should that name be sounded more than yours?
Write them together, yours is as fair a name;
Sound them, it doth become the mouth as well;
Weigh them, it is as heavy; conjure with 'em,
Brutus will start a spirit as soon as Caesar.
Now, in the names of all the gods at once,
(Jul. Caes., I, ii, l. 142, &c.)

Here seven consecutive verses have their second units triple: is one of their syllables supernumerary? The metrical construction of the words "why should that name," "write them together," "Brutus will start," is identical with the metrical construction of "sorrow and pain": either all or none contain supernumerary syllables. Collocations of four syllables like "why should that name," where the first and last only are stressed, are called "choriambs," as though they constituted a complete unit; but they are nearly always preceded by a pause. One example from "Paradise Lost" may be given here:—

(45.) So numberless were those bad angels seen
Hòvering on wìng ùnder the còpe of hèll, (i, 345.)

Here two choriambs come together, and a distinct pause separates them, unless the verse be read,—

(45*a*.) Hovering on wing undèr the còpe of hèll,

---

* They are, as Milton himself expresses it,—

thrown out, as supernumerary
To my just number found.

This could never have been intended; the rimed words "hovering" and "wing" would never have been allowed by Milton. The verse may be read,

(45*b*.) Hòvering on wing undèr the cope of hèll.

where one choriamb is retained, and the word "under" is irregularly accented. I think, however, the reading should be as in (15), where a pause —even though only slight—separates the choriambs, and a pause also comes between the first choriamb and the stressed last word of the preceding line. This pause is an integral part of the rhythm, and the choriamb should be resolved into two units, one consisting of a pause and a single stressed syllable, the other of three syllables. The construction "hovering on wing" at a verse-opening is very common in Milton and Shakspeare, and it will be found that a pause invariably separates the stressed first syllable of such opening from the stressed last syllable of the previous verse. Now, where such choriambs occur in Milton, they are never clipped; they are regarded as a combination of two units, a trochee followed by an iamb, and the pause is left out of count. The following example must be excepted:—

(46.) He ended frowning, and his look denounc'd
Dèsp'rate revènge, and battle dangerous
To less than Gods. (P.L., ii, 107.)

But this has been clipped only because the choriamb would otherwise contain *five* syllables. The leaving out of count of the pause preceding the choriamb would, in case of clipping, reduce the number of syllables in the verse to nine; and this would violate an old rule that such verse should never have less than ten syllables. It was also a rule, but a rule to which necessity compelled exceptions, that the verse should not have more than ten syllables; therefore it is that verses may be found with two clipped triple units:

(47.) on thee
Impress'd *th' effulgence* of his *glory' abides*, (P.L., iii, 388.)
Transfus'd on thee his ample Spirit rests.

The fact that choriambs are not usually clipped seems conclusive evidence of the fact that they were looked on as trochee and iamb combined, and that the pause was disregarded. The following verses from "Paradise Lost" contain two choriambs:

(48.) *a. Hovering on wing under the cope* of Hell, (i, l. 315.)
b. Squat like a toad, close at the ear of Eve, (iv, l. 800.)
c. Moors by his side under the lee, while night (i, l. 207.)
Invests the sea, and wished morn delays:

The only pause considered at all was the caesura, or natural break in the verse, which is not a part of the rhythm, but a slight suspension of it, as the pause 𝄐 is in music. It was never supposed that a pause might take the place of a syllable, though a study of the then despised ballad might have taught the possibility of it. Consider the following lines from "A Lytell Geste of Robyn Hode":—

(49.) And loke your hertes be seker and sad
Your stryngës trusty and trewe. (fytte 4, st. 11.)

In the second line, divided thus—

(49*a*.) Your stryn/gës trus/*ty and trewe*/

—there is a triple unit ; and a unit ending a line in this way is of frequent occurrence :—

(50.) *a.* Dwelled styll/ full ma*ny a day* .
b. They rode′ up in *to the towne* ′.
c. And bad them mer/*ry to be*/.

In example (19) there is a word, "strynges," which, originally a word of two syllables, is now a word of one syllable ; and the line would now be read,

(19*b.*) Your strings′ trus/ty and true′,

where a pause takes the place of the dropped second syllable of "strynges," and the triple unit is still present. Is not this construction identical with the following ? –

on wing/ un/der the cope/
a toad/ close at the ear/
his side/ un/der the lee/.

18. Disregarding the pause, the following verses from "Paradise Lost"—

(51.) *a.* and thou profoundest Hell
Receive thy new possessor : one who brings
A mind not to be chang'd by place or time. (i, 253.)

b. to fall off
From their Creator, and transgress his will
For one restraint, lord of the world besides ? (i, 32.)

c. what in me is dark
Illumin, what is low raise and support ; (i, 23.)

—would be scanned—

(51*a.*) *a.* A mind/ nòt to/ be chàng'd/ by plàce/ or time/.
b. For òne/ restràint/, lord of/ the wòrld/ besides ?/
c. Illù/min, whàt/ is lòw/ raise and/ suppòrt/ ;

The natural pause following each of the words "mind," "restraint," and "low" is disregarded, the consequence being an entirely unexpected metamorphosis. The verses, instead of being heroic or five-stressed verses, have practically become romance or four-stressed lines containing two triple units, one of which is composed of an unaccented, an accented, and a stressed syllable, as in the following lines from Shelley's "Sensitive Plant" :-

(52.) 1, *a.* The sàp shrànk/ to the ròot/ through èv/ery pòre/ (Pt. iii, l. 88.)
b. The dàrk gràss/ and the flòwers/ amòng/ the gràss/. (*Ib.*, l. 13.)
c. Like yòung lò/vers whom youth/ and lòve/ make dèar/ (Pt. i, l. 68.)
2, *a.* To ròof/ the glòw-wòrms/ from the evè/ning dèw/. (Pt. i, l. 57.)
b. The wà/ter blooms ùn/der the riv/ulèt/ (Pt. iii, l. 42.)
3, *a.* Broad wà/ter li/lies lày trèm/ulouslỳ/, (Pt. i, l. 45.)
b. Brought plèa/sure thère/ and lèft pà/ssion behind/. (Pt. ii, l. 21.)

Each of these lines contains two consecutive triple units. In the former of these units the syllable bearing the stress is preceded by a syllable bearing a syntactic accent ; this accent is only slightly less marked than the stress. In what respect do Milton's verses, read without the pause, differ from Shelley's lines coupled with them in the following pairs ?- -

(53.) *a.* Like yòung lò/vers whom yoùth/ and lòve/ make deàr/
A mìnd nòt/ to be chang'd/ by plàce/ or tìme/.

b. To ròof/ the glòw-worms/ from the ève/ning dèw/.
For one/ restraint, lòrd/ of the wòrld/ besides ?/

c. Brought pleà/sure thère/ and lèft pà/ssion behind/.
Illù/min ; whàt/ is lòw raise/ and suppòrt/ ;

This result must follow if there is not sufficient vocal pause between the two syllables bearing the rhythmic stress; and through this result the first stress is converted into a syntactic accent only. It may be held that in Shelley's lines there are also choriambs: that (53) *a* should read,—

(53*a*.) *a*. Like young/ lovers/ whom yòuth/ and lòve/ make dèar/

But, as a five-stressed or heroic verse results, this clearly cannot be right. It will be found that if Shelley's lines be repeated to beaten time, by tapping with the foot or otherwise, making the stresses fall with the beats, the syllables of (53) *a* falling with the beats will be "lo" of "lovers," "youth," "love," and "dear"; of (53) *b*, "roof," "worms," "eve" of "evening," and "dew"; and, as the intervals of time separating the beats are equal, it follows that the units between the stresses that fall with the beats must be temporally equal also, whatever they may be syllabically—that is, "the glow-worms" occupies no more time than "ning dew." It follows, too, that "glow" does not bear a stress, though it bears an accent almost equal to a stress.

19. Were it desired to expand Shelley's lines into five-stressed verses, then it could not be done by means of choriambs. Read aloud, however, the following pairs, being combinations of verses from "Epipsychidion" and "The Sensitive Plant":

(54.) *a*. And therefore I went forth, with hope and fear (Ep., l. 246.)
Like young lovers whom youth and love make dear

b. And as a cloud charioted by the wind (Ep., l. 290.)
Brought pleasure there and left passion behind.

c. And through the cavern without wings they flew, (Ep. l. 305.)
To roof the glow-worms from the evening dew.

The lines from "The Sensitive Plant" have acquired an entirely new character. In (51) *a* the second verse would be read in one of the following ways:—

(54*a*.) *a*. Like yòung/ lovèrs/ whom yòuth/ and lòve/ make dèar/

or

Like yòung/ lòv/ers whom yòuth/ and lòve/ make dèar/

and similarly (51) *b* as,-

(54*b*.) *b*. Brought plèa/sure thère/ and lèft/ passion/ behind/

or

Brought plèa/sure thère/ and lèft, pà/ssion behind/

and I think the latter reading in each case would be more favoured. Compare this reading with Milton's verse

(55.) Brought plèa/sure thère/ and lèft,/ pà/ssion behind/
Illù/min, whàt/ is lòw/ ràise/ and suppòrt/

--and we have evidence favouring the contention that a choriamb consists of two units, the first containing a pause and a stressed syllable; the second three syllables, the last being stressed.

20. A construction which appears to be reverse of that under consideration is seen in the verse, —

(56.) A shout that tore Hell's concave, and beyond
Frigh/ted the reign/ of Chà/os and/ òld Night/.
(P.L., i, l. 543.)

In the previous case two syllables, one accented and one stressed, preceded two syllables without either accent or stress; here the unaccented syllables come first. The construction is, however, different. In the cases considered above, as in (55), the word "low," bearing the rhythmic stress, is followed by a word "raise," also apparently bearing a stress. But it has been shown that "raise" cannot bear a stress unless it is separated by a pause from the already stressed "low" that is, two rhythmic stresses cannot come together; if no pause intervene, the second syllable receives the stress, the first syntactic accent only, and this is appreciably lighter than stress. In (56) "Night" bears the rhythmic stress, "old" bears syntactic accent. The stress on "and" has been suppressed, not on account of the syntactic accent following, for it is often suppressed when no such accent follows: it could be present in the above construction were it so desired, as may be shown by writing "thròugh òld Night" instead of "and òld Nìght." Were it desired to throw a rhythmic stress on "old," a pause would have to be inserted between it and "Night," as,

(57.) *a.* Frigh/ted the reìgn of Chà/os and old/ Night/.

b. He's speaking now,
Or mùr/muring, "Whère's/ my sèr pent of òld/ Nile?"
For so he calls me. (Ant. & Cleo., I. v, 25.)

c. Look here, and at thy sovereign leisure read
The gàr/boils shè/ awàked/; at the làst, bèst/;
(Ant. & Cleo., I. iii, 60.)

Here we get the reverse construction of (55) that is, a triple unit is followed by a unit containing a pause and a stressed syllable. The reading (57), whilst not usual, gives strength in this instance, and also in the following:—

(58.) *a.* O sòv/ran, vir/tuous, prè/cious of àll/ trèes/
In Paradise, (P.L., ix, 795.)

b. Equal in days and nights, except to those
Beyònd/ the pò/lar cìr/cles; to thèm/ dày/
Had unbenighted shone. (P.L., x, 681.)

c Give me some wine, fill full.
I drink/ to the gèn/eral jòy/ o' the whòle/ tà, ble.
(Macb., III, iv, 89.)

In the case of *c*, the construction "o' the whole" seems to demand the pause, unless it be supposed that the accent of "table" is removed from the first to the second syllable as in the example (25); but whereas "pipèr" and "aspèct" are pronunciations not improbable, "tablè" seems almost impossible. Such apparently impossible accent, however, seems intended when the word occurs in old ballads, as in "Burd Ellen"

(58*a*.) Burd Ellen was àt the byè-tablè
Amang the pages set

unless here, too, a pause is intended to separate "bye" and "table." It must be admitted that as different readers will give different readings to a certain passage, so different prosodists will give different divisions or scansions. On general laws all are agreed; differences arise with the variations of the laws; and it is wished here to suggest theories, not to formulate dogmas.

21. Supposing that in examples (51) *a*, *b*, and *c*, for the words "mind," "restraint," and "low," the words "reason," "restriction," and "lowly" are substituted,—

(59.) *a.* A reason not to be chang'd by place or time,
b. For one restriction, lord of the world besides?
c. Illumin; what is lowly raise and support;

The verses are now composed of ordinary duple units with one triple unit present in each. This triple unit is temporally equal to the duple units, a fact self-evident when the verse is read aloud even without beating time. In the unit preceding the triple unit the pause has been filled with an extra syllable, and the fact that such syllable can be inserted without change of the rhythm is proof of its existence in the verses quoted in (51). In fact, the following pairs of verses

(60.) *a.* A mind′ nòt′ to be chàng'd/ by plàce or time
Pour forth′ their po/pulous yoùth/ about/ the hive (P.L. i, l. 770.)
b. For one′ restràint, lòrd/ of the wòrld/ besides/,
To sèt′ himsèlf′ in glò′ry abòve/ his pèers/, P.L., i, l. 39.)
c. Illù/mine; whàt′ is lòw/ ràise/ and support′;
In wòrst′ extrèmes/ and òn/ the pèr ilous èdge/ (P.L., i, l. 276.)

differ only in one unit: the second in *a*, the third in *b*, and the fourth in *c*. The one unit is composed of a pause and a stressed syllable; the other of two syllables, the second stressed. Rhythmically, then, the pairs are exactly alike; the only difference is syllabic.

22. The same is true when the choriamb composes a whole stanza, as in Thackeray's "Mahogany Tree":

(61.) Christmas is here:
Winds whistle shrill,
Icy and chill,
Little care we:
Little we fear
Weather without,
Sheltered about
The Mahogany Tree.

Every line is composed of a choriamb, with the exception of the last in each stanza. But is the pause dividing the lines to be disregarded? This pause is absent after the seventh line, *and its place is taken by the two syllables opening the eighth.* The eighth line is composed of two triple units; and the inference is that *every* line of the stanza is likewise composed of two triple units, though, in seven out of eight, pauses take the place of syllables. This conclusion also applies to Shakspeare's verses quoted in (44): each verse is preceded by a pause, and the choriambs are broken into two units, the first paused, the second triple. The following verses from "Paradise Lost" are distinctive:

(62.) Abolish his own works. This would surpass (ii, l. 370.)
Common revenge, and interrupt his joy

Are not the pauses here unmistakable?

(62*a.*) Abòl ish his/ own wòrks/. This/ would surpàss
Còm/mon revènge/, and in/terrùpt/ his jòy/

The pause is by no means so decided as in Thackeray's lines, for in Milton the construction does not often come in repeated succession, and the pause in a verse consisting mainly of duple units is not so marked as a pause where the units are mainly triple in one instance it represents one syllable, in the other two. In the verses,

(63.) But hè/ once pàst/, soon af/ter when/ màn fèll,
*Strànge/ alterà,*tion! Sìn/ and Dèath/ amàin
Fol/lowing his tràck/, *sùch/ was the wìll/* of Heav'n′,
Pàved/ after hìm/ a bròad/ and bèa/ten wày/
O/ver the dàrk/ abỳss/, whose boil/ing gùlf/
Tàme/ly endùred/ a bridge′ of wòn/d'rous length/,
(P.L., ii, l. 1023, &c.)

the effect is not altogether displeasing; not more than two choriambs can come together in the five-stressed verse, so that the triple effect cannot be so obtrusively accumulated as in Thackeray's "Mahogany Tree."

23. The construction is slightly varied when the triple unit does not immediately follow the paused unit:

(64.) *a.* Soon had his crew
O'pen'd ìn/to the hìll/ a spà/cious wòund/,
And digg'd out ribs of gold. (P.L., i, 689.)

b. Let us not then pursue
By force impossible, by leave obtain'd
Ùn/accèp/table, though/ in Heàv'n/, our stàte/
Of splendid vassalage; (P.L., ii, 251.)

c. Which would be all his solace and revenge,
Às/ *a* despìte/ *dòne/ agàinst/ the Mòst Hìgh/,*
Thee once to gain companion of his woe. (P.L., vi, 906.)

In example *c* the paused and triple units are most unmistakable, owing to the former coming within the verse; both exist as certainly in *a* and *b*. The content of *a* is quoted:

(64*a*.) Rifled the bowels of their mother earth
For treasures better hid. Soon had his crew
O'pen'd ìn/to the hìll/ a spà/cious wòund/,
(P.L., i, l. 68, &c.)

The pause before "open'd" would have disappeared had the preceding verse been given a feminine ending, as,

(65.) but who here
Will envy whom the highest place exposes
Foremost to stand against the Thunderer's aim,
(P.L., ii, l. 26, &c.)

In the examples quoted in (64) one unit separates the paused and triple units. In the following, from Shelley's "Epipsychidion," they are separated by two units—

(66.) until thought's melody
Become too sweet for utterance, and it die
In words, to live again in looks, which dart
With thrilling tones into the voiceless heart,
Hàr/monì/sing sì/lence withòut/ a sound/ (Ep., 564.)

— and were "despite" accented on the first syllable, as it is not inconceivable Milton intended it to be accented in example (64) *c*, the paused and triple units would be separated by three units

(67.) *Às/ a dès/pite dòne/ agàinst/ the Mòst Hìgh/.*

The accent would not be "wrenched" were "an insult" substituted for "a despite," and the rhythm is neither awkward nor unnatural. Again, were "Highest" substituted for "Most High" in (67), a verse trochaic in effect throughout would result:—

(67*a*.) Às a dèspite dòne agàinst the Hìghest.

That such a verse is not repugnant to a poet's ear is certain; for in "Hyperion" Keats introduces one exactly similar, and in "Macbeth" Shakspeare introduces one almost similar:—

(68.) *a.* and there shall be
Beautiful things made new, for the surprise
Of the sky-children; I will give command:
Thea! Thea! Thea! where is Saturn?
(Hyp., Book i, l. 131.)

b. As justice, verity, temperance, stableness,
Bounty, perseverance, mercy, lowliness. (Macb., IV, iii, 93.)

Though broken, Shakspeare's verse from "Antony and Cleopatra" may also be quoted:

(69.) *Cæs.* With most gladness:
And do invite you to my sister's view.
Whì/ther straight/ I'll lèad/ you.
Ant. *Lèt/ us, Lèpidus.*
Not lack your company. (Ant. & Cleo., II. ii. 171.)

Did the verses in (68) begin "But Thea! Thea!" and "And thither straight I'll," they would be similar in construction to the middle verse of (65). A parallel construction in ballad verse has already been quoted- No. (13) of this section. Without the feminine ending they would result in verses containing the regular number of stresses- five- *but only nine syllables*; as.—

(70.) thrice from the banks of Wye
And sandy-bottom'd Severn have I sent him
Bòot/less hòme/ and wèa/ther bèa/ten bàck,.

Here the missing first syllable is found in the feminine ending of the preceding verse. Milton allowed no nine-syllabled verse of any kind in "Paradise Lost" or "Paradise Regained." Bohn's 1852 edition has a verse—

Indeed? hath God then said, of the fruit
of all these garden trees

But reference to Newton's edition of 1773 shows that it should be

Indeed? hath God then said that of the fruit

And so of other verses of nine syllables: they prove misprints. Even Milton, then, bowed to the tyranny of "numbers" in so far that he never permitted less than ten syllables to a verse; Dryden and Pope were bowed yet lower--not only did they never permit less than ten, but they attempted to permit no more.

24. "Wrenched accent" has been spoken of in connection with quotation (66). The term has been applied to cases where words naturally accented, say, on the second syllable are apparently by the metre required to be accented on the first. Paragraphs 9 and 10 of this section have in part considered this subject. It has been pointed out that many words to which an apparently "wrenched accent" must be given are more naturally treated by a spreading of the accent over both syllables. Thus Shelley's verse in "Epipsychidion."

(71.) Scarce visible from extreme loveliness, (l. 104.)

should perhaps receive neither of the following renderings -

(71*a*.) *a*. Scarce vì/sible′ from èx/treme lovè/liness/
b. Scarce vì/sible,′ from extrème/ lovè/linèss,′

—where in the first instance the rhythmic stress is on the first syllable and the natural syntactic accent entirely removed from the second syllable. and in the second instance the rhythmic stress and syntactic accent both fall on the second syllable, producing a triple unit followed by a paused unit. The most natural reading is—

(71*b*.) Scarce vì/sible,′ from èx/trème lòve/linèss/

where both stress and accent are present. There are instances, however. where this construction is impracticable. In the verse,

(72.) With breasts palpitating and wings refurled,

the use of a vocal pause seems obligatory: the reading.

(72*a*.) With brèasts/ pàl/pità/ting and wings/refurled/.

seems infinitely superior to either of the two

(72*b*.) *a*. With brèasts/ palpit 'ating/ and wings/ refurled '.
b. With brèasts ' pàlpit 'àting and wings ' refurled '.

These seem intolerable. The pause in (72*a*) is hardly perceptible, it is so well filled with the consonantal termination of "breasts," and the word "palpitating" receives its natural accents. It has been held that poets have intentionally set words into places in the rhythm where the stress and accent will come into conflict, with the object of overriding the prose accent. This has palpably been done by Shelley in "The Sensitive Plant" and "Epipsychidion":

(73.) *a*. For each òne was *interpenetrated* (S.P., Pt i, l. 66.)
With the light and the odour its nèighbour shèd,
b. By Lòve, of light and mòtion: one intènse
Diffùsion, òne sèrene *Omnipresence*, (Ep., 94, 95.)

He has put his intention beyond doubt by riming with the misaccented words: but such instances are rare, and in the majority of cases where the words occur within the verse it is certainly preferable to suppose the poet intended to vary the metre rather than the pronunciation of the word. As has been seen, two-syllabled words accented on the second syllable, which appear to be in a state of accent fluctuation, will allow accent on the first syllable instead of on the second, and consequently on both syllables. Such words are at times found in apposition, as in Milton's verses

(74.) and from despair
Thus high uplifted *beyond* hope, aspires
Beyond thus high, insatiate to pursue (P.L., ii, 7, 8.)

And even here it will be found that the first "beyond" retains somewhat of its syntactic accent on the second syllable whilst the first bears the rhythmic stress. The following is perhaps doubtful:

(74*a*.) O *Goodness* infinite, *Goodness* 'immense! (P.L., xii, 469.)

25. In the great majority of cases where paused and triple units come together, the former precedes the latter: the apparently reverse construction was considered in paragraph 20. In the following verse the triple unit precedes:

(75.) *a*. and some I see
That twofold balls and treble sceptres carry:
Hòr/*rible sight* // *Now*/ I sèe/ 'tis trùe/ ;
For the blood-bolter'd Banquo smiles upon me,
(Macb., IV, i, 122.)
b. Rail thou in Fulvia's phrase, and taunt my faults
With sùch/ full lì/cense as bòth/ trùth/ and mà/lice
Have power to utter. (Ant. & Cleo., I, ii, 113.)

In *a*, a doubt can hardly enter that a paused unit succeeds a triple; many may prefer to scan *b*—

(75*a*.) *b*. With sùch/ full lì/cense as/ bòth trùth/ and mà/lice

—suppressing the stress on "as" and giving "both" its syntactic accent and "truth" its stress. Even with this scansion I think it will be found, in reading aloud, that a vocal pause will be made between "both" and "truth."

26. The question is, seeing that triple units are ineradicable from what is called "two-syllabled" verse—that the two-syllabled units in such verse are constantly replaced by units of three syllables—are those three-syllabled units intrusions? Are they not rather incontrovertible assertions that

all duple units are potentially triple if, indeed, duple metre (by which is meant the "two-syllabled,") be not only potentially but fundamentally triple ? There can be no doubt that in many, if not most, of the old ballads our most virile form of poetry two-syllabled and three-syllabled units are mixed so indiscriminately that it is impossible to class those ballads either as duple or triple. The fact is that, mixed as the metre is, it is yet homogeneous; so that either it is duple metre with protean units capable of assuming a disguise in triple form, or *vice versa*. The various combinations in which it is possible for triple units to appear in duple verse have been listed: as, duple verses with one unit triple, in any unit from the first to the seventh; with two units triple the first and second, first and third to first and seventh, second and third to second and seventh, and so on; with three units triple the first second and third, first second and fourth to first second and seventh, second third and fourth, and so on; with four, five, six, and seven units triple, in all the various combinations. In a range restricted to Ritson's collection of "Robin Hood" ballads and Allingham's "Ballad Book" every combination but four was found, the four being verses with triple units in units

1, 2, 3, 5, and 7;
1, 2, 4, 5, and 6;
1, 2, 5, 6, and 7; and
1, 3, 5, 6, and 7:

and without doubt if more extensive search were made these too could be found. They could, of course, easily be invented; but actual specimens that have survived the struggle for existence are necessary as types of vital forms.

27. The conclusion is that absolutely no line of demarcation can be made between duple and triple. When an isolated triple unit appears in duple verse it is often explained as a "triplet"—three syllables occupying the "time" of two. This is nomenclature only, not explanation. An isolated duple unit in the midst of triple verse is called a defective triple unit. It is admitted by all that in these isolated cases the "time" of the intruding unit is neither more nor less than that of the surrounding units: the rhythmic time is constant, and each rhythmic unit may carry one, two, three, and, as will be seen in the following section, four or more syllables. Purists have endeavoured to separate the inseparable: they have held that duple verse should contain no triple units, and that triple verse should contain no duple units; but the latter rule at least they have been obliged to relax with licenses. Ever and again the Muses have scorned their futile endeavours, so that whom the Muses loved the purists chastised. Coleridge's "Christabel," Shelley's "Sensitive Plant" what are these but triumphant assertions of the oneness of the duple and triple measures ?

Section IV.

1. A most indubitable pause divides the duple unit in verses such as,—

(1.) *a.* *Ò*, *yèt*// I do repent me of my fury,
That I did kill them. (Macb. II, iii, 112.)

b. *Wèll.* *Lèt's*// away and say how much is done. (Macb. III, iii, 22.)

c. So Satan spake, and him Beelzebub
Thus àn/*swer'd.* *Lèa*/der of those armies bright. (P.L., i, 272.)

d. for now the thought
Both of lost happiness and lasting pain
Tormènts/ *him ;* *round*/ he throws/ his bàle/ful èyes/, (P.L., i, 56.)

e. And make my seated heart knock at my ribs
Against the use of nà/*ture ?* *Prè*/sent fèars/
Are less than horrible imaginings. (Macb. I, iii, 137.)

f. rolling in the fiery gulf.
Confounded though immor/*tal :* *But*/ his doom//
Preserv'd him to more wrath. (P.L., i, 53.)

These may be called divided duple units. As noted in paragraph 17 of Section III, such pauses dividing *triple* units caused the name "hypermetrical" or "supernumerary" to be given to one of the syllables of the unit. In the following verses the pause falls after the first, or so-called "hypermetrical" syllable: –

(2.) *a.* are you aught
That man may quès/*tion ?* *You sèem*/to understand me.
(Macb., I, iii, 43.)

b. The rest is là/*bour,* *which is*/ not used for you:
(Macb., I, iv, 44.)

In the following verses, however, the pause falls after the second syllable:

(3.) *a.* from his sight receiv'd
Beatitude past ù/*tterance ;* *òn*/ his rìght/
The radiant image of his glory sat. (P.L., iii, 62.)

b. our graver business
Frowns at this lè/*vity.* *Gèn*/tle lords, let's part;
(Ant. & Cleo., II, vii, 128.)

In these it would be difficult to say which is the hypermetrical syllable, though an indication is afforded by a verse in Newton's Milton:

(3.) *b.* The good befall'n him, author unsuspect, (P.L., ix, 771.)

The dropping of the "e" in "befallen" removes the unit from the category of those exampled in (3) *a*, and suggests that vowels in the other words might also be dropped, making "utterance" "utt'rance." Is such barbarity preferable before the divided triple unit? Again it is a question of individual taste in reading; and if some, even a few, readers prefer to consider the words unmutilated, then the divided triple unit, as well as the divided duple, must be admitted by prosodists. A divided triple means a triple unit whose syllables are separated by a pause, and so with a divided duple: a paused duple unit is one composed of a pause and a syllable; a paused triple would simply be duple.

2. The question that arises is, seeing that the pause in the duple unit is an indication of potentiality towards a triple unit, is the pause in the triple unit an indication of potentiality towards a quadruple unit? The logical answer must be in the affirmative. There is no doubt that quadruple or four-syllabled units do occur not only in the unpolished yet invaluable ballads, but in the perfect and exalted verse of Shakspeare and Milton. Again examples are best evidence:—

(4.) *a.* abash'd the Devil stood,
And felt how awful goodness is, and saw
Vìr/*tue in her shàpe*/ how lovely; saw, and pin'd
His loss; (P.L., iv, 847.)

and Antony,
Enthron'd i' the market-place, did sit alone,
Whis/*tling to the àir*/, which, but for vacancy,
Had gone to gaze on Cleopatra too, (Ant. & Cleo., II, ii, 221.)

It may perhaps be admitted that such units do occur in isolation, whilst it is at the same time contended that for these to be other than exceptions it must be proved that the quadruple unit forms a basic unit in metrical schemes.

3. The proof is not, I think, impossible, and Australian poetry especially furnishes evidence. The more popular poetry of Australia is here referred to poetry that sells in editions of tens of thousands. In spirit, as in popularity, it more nearly approaches the old English ballad—the ballad of humour, however, not of tragedy. Even in the best of the old ballads triple units constantly occur, and where the blending of duple and triple is artistic the effect is most pleasing. The triple units impart a "rapid" movement to the metre; and as the themes become more humorous, treating of the lighter rather than the more serious side of life, as in the Robin Hood ballads, this rapidity of movement becomes more and more marked, until many of the ballads are entirely triple. It was probably of the shallow jigging ballads that Shakspeare spoke through Hotspur in Henry IV:-

(5.) I had rather be a kitten and cry mew,
Than one of these same metre ballad-mongers.

Quadruple units also occur in the old ballads, but not in very great abundance; their effect is proportionately more rapid than that given by triple units. The Australians, lovers of the horse and outdoor sport, loved and do love rapidity of motion; and it is natural that they should choose a metre that will give to their verse the exuberance of motion which they feel in daily life: triple metre was favoured, until supplanted by the even more rapid quadruple.

4. Lindsay Gordon stands father of the popular Australian poetry. Out of his sixty-seven collected poems, forty-five are triple, whilst only eighteen are duple. In four poems can be traced the germ of what was to become a dominant metre in Australian poetry: these four are "Unshriven," "Whisperings in Wattle-boughs," "A Hunting Song," and his well-known and well-loved "Sick Stockrider." The metre has been more developed by later writers, among them the favourites Paterson and Lawson. Paterson's first book opens with and takes its name from a piece in this very measure, "The Man from Snowy River." Here the beat is much more distinct than in Gordon:

(6.) There was movement at the station, for the word had passed around
That the colt from old Regret had got away,
And had joined the wild bush-horses - he was worth a thousand pound,
So all the cracks had gathered to the fray.

The usual reading of this stanza would require a stress on the first, third, and every odd syllable; but if it be so read it is instinctively felt to be quite wrongly read the lilt is broken, the life is lost. Drop the first stress, however, the third, fifth, and every odd stress, and the dry bones of metre are vivified by the flowing life of verse:—

(7.) There was movè/ment at the stà/tion, for the wòrd/ had passed aròund/
That the còlt/ from old Regrèt/ had got awày/.

There is a slight stress on "passed," "old," and "got," but quite a subordinary stress; in fact, the stress has become a mere accent, and we have an expansion of the unit "old Night" in quotation (56) of Section III. The rhythm would be the same did we write,

(7*a*.) There was mòve/ment at the stà/tion, for the wòrd/ pàssed ròund/, this being the metre of Gilbert's

(8.) From a chèap/ and chippy cho/pper on a big/, black block/.

Here "passed round" and "black block" are almost identical with "old Night."

5. The following is half of the second stanza of "The Sick Stockrider" :—

(9.) Now westward winds the bridle-path that leads to Lindisfarm,
And yonder looms the double-headed Bluff;
From the far side of the first hill, when the skies are clear and calm,
You can see Sylvester's woolshed fair enough.

In this stanza, as has been noted above, the dropping of stresses is not so pronounced as in Paterson's stanza (6), but no reader would give the even stresses the same value as the odd ones, and in parts of the stanza every reader would suppress certain of them –

(9a.) From the fàr side of the first hill, when the skies are clèar and càlm,

Furthermore, the dropping of the even stresses in Gordon's stanza gives us lines of four and three stresses alternately ; giving every stress full value, the lines are of seven and five stresses alternately a very rare combination. By dropping the alternate stresses, however, a pure ballad stanza results : a most unusual metre is changed to one most familiar, its only strangeness on first reading being its quadruple units. The Australian has, indeed, adopted the favourite measure of his ancestors, changing its externals, but not its essentials, in the process of acclimatisation.

6. In Paterson's stanza the odd stresses, but in Gordon's the even stresses, are suppressed. Given its full tale of stresses, Paterson's stanza would be trochaic ; Gordon's, iambic. Of Gordon's four quadruple pieces, two are in apparent iambs, one in trochees, whilst one is mixed ; of Paterson's and Lawson's forty quadruple pieces, three only are in iambs, thirty-four in trochees, and three are mixed. Gordon has therefore been departed from so far as the original metre is concerned ; the trochaic measure resolved itself into the quadruple much more frequently than the iambic. The reason probably is that in choosing the former, where the suppression of the first stress gave an initial unit of three syllables, an easier transition to the four-syllabled unit was obtained. The popularity of the quadruple metre may be seen from the fact that in Paterson's two volumes of verse, "The Man from Snowy River" and "Rio Grande's Last Ride," in eighty-one pieces twelve are quadruple ; in Lawson's two volumes, "In the Days when the World was Wide" and "Verses Popular and Humorous," in one hundred and fourteen pieces twenty-eight are quadruple ; Ogilvie, in "Fair Girls and Grey Horses," has eleven in a hundred ; Boake, in "Where the Dead Men Lie," has four in thirty-two ; Brunton Stephens, in "Poetical Works," has the high average of twelve in fifty-seven.

7. Two quotations may be taken as contrasts of the original metre and its Australian development. In Kendall's imaginative and musical poem "Hy-Brasil" occur the lines,—

(10.) There indeed was singing Eden, where the great gold river runs
Past the porch and gates of crystal, ringed by strong and shining ones !
There indeed was God's own garden, sailing down the sapphire sea—
Lawny dells and slopes of summer, dazzling stream and radiant tree !

Here it is impossible, except in perhaps two instances, to slur or suppress the odd stresses ; but read in the same full-stressed way the following from

Lawson's "Australian Bards and Bush Reviewers," and instead of humorous they are ridiculous : -

(11.) If you sing of waving grasses where the plains are dry as bricks,
And discover shining rivers where there's only mud and sticks ;
If you picture " mighty forests " where the mulga spoils the view—
You're superior to Kendall, and ahead of Gordon too.

8. There are, of course, many English poems with suggestions of the quadruple metre, and it is these suggestions that the Australian has taken, forming from them a basic quadruple unit. The loose lilt is evident in the Hon. Mrs. Norton's " Bingen on the Rhine," and it gives charming effects to S. Ferguson's delightful Irish ballad " The Fairy Thorn " :—

(12.) They're glancing through the glimmer of the quiet eve,
Away in milky wavings of neck and ankle bare ;
The heavy-sliding stream in its sleepy song they leave,
And the crags in the ghostly air.

Christina Rossetti's " Amor Mundi," too, is on the verge of the quadruple metre ; parts, indeed, have crossed the border-line :—

(13.) " O where are you going with your love-locks flowing,
On the west wind blowing along this valley track ? "
" The downhill path is easy, come with me an it please ye,
We shall escape the uphill by never turning back."

9. When the quadruple unit makes its appearance in triple metre, as in Scott's stanza, -

(14.) He is gone on the moun*tain*,
He is lost to the fo*rest*,
Like a summer dried foun*tain*,
When our need was the sorest.

—it is evident that it is caused only by the feminine rimes, which add a syllable to the following triple unit. In Scott's stanza this occurs in the middle of the verse as well as at the end : -

(14*a*.) He is gone on the moun*tain*, *he is lost* to the fo*rest*,
Like a summer dried foun*tain*, *when our need* was the sorest.

The quadruple unit is twice avoided in the above stanza by taking one of the syllables from the three-syllabled unit following the feminine rime. These avoidances come as reliefs in reading : the stanza has certainly a not altogether unpleasing strangeness ; but its very rarity shows that it is an unnatural form.

10. It is admitted that when the quadruple unit is most apparent in Australian poetry that poetry is not the highest. It is, however, the *form* that is under consideration rather than the spirit ; and for laws of form a nursery-rime is as valuable as play of Shakspeare, an Australian ballad as an epic of Milton. In verse like " Constable M'Carty's Investigations," by Lawson, there is absolutely no room for doubt of the existence of the quadruple unit :

(15.) Most unpleasantly adjacent to the haunts of lower orders
Stood a " terrace " in the city when the current year began,
And a notice indicated there were vacancies for boarders
In the middle house, and lodgings for a single gentleman.

It may be objected that when the unit is thus proved to exist the poetry is at the same time proved not to exist ; but the triple unit was once in like manner considered incapable of being made the vehicle of elevated poetry, and was banished. Keats, a poet of keenest vision in duple metre, was a poetaster in triple ; but from the days of Cowper the triple metre has been endowed more and more with the highest spirit of poetry. Does it not receive the perfect spirit of life at the hands of Swinburne in "Itylus," and are not the duple and triple measures perfectly blended by him in "An Interlude"? Nor is the quadruple metre without indications of what it may throb to under master hands. The following lines are from Paterson's "Clancy of the Overflow":

(16.) And the bush hath friends to meet him, and their kindly voices greet him
In the murmur of the breezes and the river on its bars,
And he sees the vision splendid of the sunlit plains extended,
And at night the wondrous glory of the everlasting stars.

The majestic sweep of this unit is here filling with melody: another stop has, without doubt, been added to the organ of poesy.

11. In the same way as the duple and triple units, the quadruple may contain one syllable accented and one stressed, as in (16):

(16*a*.) And the bùsh/ *hath friends to mèet//* him, and their kìn/*dly vòices grèet/* him
In the mùr/mur of the bree/zes and the rì/ver on its bàrs/,
And he sèes/ *the vision splèn//*did of the sùn/*lit plàins extèn/*ded,
And at night/ *the wòndrous glò//*ry of the è/verlasting stars/.

This alternation of light and heavy units gives a most pleasing effect. In the heavy units the unaccented syllables may be dropped, when a unit of two syllables, one accented and one stressed, results, differing from the ordinary heavy duple unit in the words being somewhat more separated with pauses. Such unit was exemplified in (7*a*) and (8) of this section. The following stanza shows it in its Australian form:—

(17.) When you're lỳ/ing in your hàm/mock, slèeping sòft// and slèeping sòund//,
Withòut/ a càre or tròu//ble on your mind/,
And there's nò/thing to distùrb/ you but the èn/gines gòing ròund//,
And you're drèam/ing of the girl/ you lèft behind//,
In the mì/ddle of your jòys/ you'll be wà/kened by a noise/,
And the clà/tter on the dèck/ abòve your cròwn//,
And you'll hèar/ the còrporal shòut// as he tùrns/ the picket oùt/,
"There's anò/ther blèssed hòrse// *fèll dòwn//*."
(*Paterson*, "There's another blessed Horse fell down.")

Units such as the third and fourth in the first line may be called "heavy quadruple units"; those like the last unit of the last line, "paused heavy quadruple units."

12. Is a unit possible that shall contain more than four syllables? Isolated examples do occur. These again are found in the lightest and least-elevated forms of verse; but, as they *are* found, they must be noted. An example at the division of the verse may be found in Canning and Frere's "Ballynahinch," stanza 2:—

(18.) The great stàte/sman, it sèems/, has perùsed/ all their fà/*ces,*
And being mì/ghtily strùck/ with their lòy/al grimà/ces;

and in Dibdin's "The Showman's Catalogue of Living Animals," stanza 2:—

(19.) Here's brù/in, the beàr/, not fà/mous for grà/*ces, O!*
And his hùg's/ like Mounsèer's/ fratèr/nal embrà/ces, O!

In stanza 1 of Dibdin's poem such a unit occurs within the line,—

(20.) We've rare spècies of mònkeys, of sòrts nearly twènty;
Though a mòn/key's no rà/*rity, for in tòwn*/ there are plèn/ty;

Dibdin's stanzas are in the "Museum of Mirth," and are presumably still sung, so these units cannot be considered as having been perpetuated merely through having been printed. They will be seen to be quite different from the units where a stress has been suppressed between a duple and triple unit; and so crude are they generally that it is thought to be sufficient to note their existence.

Section V.

1. The units hitherto considered have mainly been those containing one stressed syllable. Units containing two syllables neither stressed nor accented are, however, of frequent occurrence. These, in classic nomenclature, are "pyrrhics," but may be better named "light duple." In the following examples a stress has been suppressed in each verse, so that each contains a light duple unit:

(1.) *a.* Man hath his daily work of body or mind
Appointed, which declares his dignity,
And the/ regàrd/ of Hèav'n/ on àll/ his wàys/; (P.L., iv, 620.)

b. O fàir/*est of*/ creà/tion, làst/ and bèst/
Of all God's works, (P.L., ix, 896.)

c. 'Tis goòd/ you knòw/ *not that*/ you àre/ his heirs/;
(Jul. Caes., III, ii, 150.)

d. Hè/ shall but bèar/ *them as*/ the àss/ bears gòld/,
(Jul. Caes., IV, i, 21.)

In the following examples two stresses are suppressed in each verse:—

(2.) *a.* *It is*/ a crèa/*ture that*/ I teach/ to fight/.
(Jul. Caes., IV, i, 31.)

b. And, being men, hearing the will of Caesar,
It will/ inflàme/ *you, it*/ will màke/ you màd/:
(Jul. Caes., III, ii, 149.)

c. To-mòr/*row, and*/ to-mòr/*row, and*/ to-mòr/row,
Creeps in this petty pace from day to day,
To the/ làst sỳl/*lable of*/ recòr/ded tìme/;
(Macb., V, v, 19–21.)

d. They did/ *so, to*/ the amà/*zement of*/ mine èyes//,
That look'd upon't. (Macb., II, iv, 19.)

A unit of four or five syllables might be inferred, were it not for the fact that the verses would then lack their normal five units. It is questionable, however, if there is any great material difference between these apparently quadruple and the actual quadruple units. The fourth unit in

(3.) Our àr/my lies/ rèa/*dy to give ùp*/ the ghòst/.

seems temporally almost equal to units three and four in

(3*a*.) Of dìre/ combùs/*tion and*/ *confùsed*/ evènts/

If it be equal, then (3*a*) and verses like it must be regarded as verses of only four stresses, when, also, blank verse must be regarded as not uniformly composed of verses of five stresses. A four-stressed line and a verse from "Paradise Lost" may be juxtaposed:—

(4.) And the rose like a nymph to the bath addrest,
O fairest of creation, last and best

Here, however, the latter appears to be too much hurried, so that it is presumable that the time taken from the second unit is divided amongst the others, leaving the verse of comparatively the same temporal length as those of five normal stresses. Example (3) will more readily transform to a four-stressed line -

(3*b*.) Our àr/my lies rèa/dy to give/ up the ghost/

—since the loss of a pause is not so noticeable in this instance as the cramping of syllables in (1 The whole question of the relationship between the italicised units in (3) and (3*a*) is very debatable: but it will, I think, be agreed that the units with suppressed stress give part of their time to the other units, adding emphasis. This is especially noticeable in verses like (2) *c*–

To the/ làst sỳl//lable of/ recòr/ded tìme/ ;

which one is almost inclined to read.

(5.) To the làst/   sỳl/lable of/ recòr/ded tìme/,

making a long vocal pause on "last," and resolving the unstressed and double stressed units into triple and paused units, similar to those discussed in paragraph 20 of Section III.

2. This possible reading with the vocal pause presents itself when the unstressed unit is followed by a unit containing both accented and stressed syllables, as,--

(6.) *a.*   a noble stroke he lifted high,
Which hung not, but so swift with tempest fell
On the/ pròud crèst// of Sà/*tan, that/ nò sight//*,
Nor mo/*tion of/ swìft thòught//*,   lèss/ could his shield/
Such ruin intercept: (P.L., vi, 191-2.

b.   Now I see 'tis true;
*For the/ blòod-bòl//*ter'd Bàn/quo smìles/ upòn/ me,
And points at them for his.   (Macb., IV, i, 123.)

c. Amongst innumerable stars, that shone
Stàrs dis//*tant, but/ nìgh hànd//* seem'd ò/ther wòrlds/;
(P.L., iii, 566.)

d.   the will
And hìgh/ permìs/*sion of/ àll-rù//*ling Hèaven/
Left him at large to his own dark designs,   (P.L., i, 213.)

e. Nor did they not perceive the evil plight
In which/ they wère/, *or the/ fìerce pàins//* not fèel/;
(P.L., i, 336.)

f. You làck/ the seà/*son of/ àll nà//*tures, slèep/.
(Macb., III, iv, 141.)

g.   What concern they?
The gèn/eral cause ?/ or ìs/ *it a/ fèe-grìef//*
Due to some single breast ?   (Macb., IV, iii, 196.)

h. Frìgh/ted the rèign/ of Chà/*os and/ òld Nìght//*.   (P.L., i, 543.)

These verses admit of various readings, nor can one be said to correct and another incorrect. Few, probably, would read them in the child's singsong,

(6*a*.) *a.* On thè/ proud crèst/ of Sà/tan, thàt/ no sìght/,

though this would at one time have received the sanction of prosodists. Some would read with a vocal pause on "proud," and another, perhaps, on "no": –

(6*b*.) *a.* On the pròud/   crèst/ of Sà/tan, that nò/   sight/,

These pauses need be but very slight to give distinctive character to the verse. Others, again, would ignore the pauses, and give "proud" and "no" their syntactic accents, the stresses being given to the following words, "crest" and "sight":—

(6*c*.) *a.* On the/ proùd crèst// of Sà/tan, that/ nò sight//,

The scansions for these three readings would be,—

(7.) *a.* On thè/ proud crèst/ of Sà/tan, thàt/ no sight/,
b. On the proùd/   crèst/ of Sà/tan, that nò/   sight/,
c. On the/ pròud crèst// of Sà/tan, that/ nò sight//,

It is immaterial for the purposes of the analysis here attempted which reading be adopted: it is only desired to show that the various units of the three scansions are possible—that is, units with two syllables, the first unaccented, the second bearing a stress; units with three syllables, the third bearing the stress; units of a pause and a single stressed syllable; units of two syllables, neither accented nor stressed; units of two syllables, the first accented, the second stressed. The last-named may be called "heavy duple units."

3. There is a variation of the triple unit when, as in the duple unit, an accented syllable precedes the stressed syllable:—

(8.) *a.* Shòw/ *you swèet Cǽe*//sar's woùnds/, pòor pòor// dùmb mòuths//.
(Jul. Caes., III, ii, 229.)

b. Whò/ *you àll knòw*// are hòn/oura/ble mèn/:
(Jul. Caes., III, ii, 129).

c. Lìs/*ten grèat thìngs*//: Brù/tus and Càs/sius/
(Jul. Caes., IV, i, 41.)

This form of the unit is mostly found in triple units following broken units: it may be called, as suggested, the "heavy triple unit." In the following example an alternative scansion presents itself—

(8*a.*) Òne/ do I pèr/*sonate* of/ *Lòrd Tì*//mon's fràme/,

—where a triple unit with suppressed stress is followed by a heavy duple unit. This scansion, however, creates a new form of unit, the light or unaccented and unstressed triple; and as this form is exceedingly uncommon, and when found can as easily be resolved into two other common units—the light duple and heavy triple—there is no necessity for such scansion as is presented in (8*a*).

4. The heavy duple unit, or duple unit in which the first syllable is accented and the second stressed, occurs with great frequency, not only following light units, or units with suppressed stress, as in examples (6) in paragraph 2 above, but following ordinary or other heavy units. These in classic nomenclature are known as "spondees." The following are examples:—

(9.) *a.* Ùp/ then crèw/ the rèd/ *rèd còck*//, ("Wife of Usher's Well," st. 8.)

b. The gòod/ *whỳte brède,*// the gòod/ *rèd wỳne*//,
And theretò/ the fỳne/ *àle browne*//.
("A Lytell Geste of Robyn Hode," fytte 7, st. 40.)

c. Him the almighty Power
Hurl'd hèad//long flà/ming from/ th' ethè/real skỳ, (P.L., i, 45.)

d. I knòw/ *yòung bloods*// lòok/ for a time/ of rèst/.
(Macb., IV, iii, 262).

e. Yet he loves Antony:
Hò! hèarts,// *tòngues, fì*//gures, scrìbes/, *bàrds, pòe*//ets, càn/not
Thìnk, spèak//, *càst, wrìte*//, *sìng, nùm*//ber—hò!/
His love to Antony. (Ant. & Cleo., III, ii, 16.)

f. No mòre/ *lìfes, dèaths*//, *lòves, hà*//treds, pèa/ces, wàrs!/
(*Browning*, "Sordello," iii, 140.)

As these examples show, the heavy units are the result of the juxtaposition of words bearing comparative equal syntactic accent, such as nouns and their qualifying adjectives, duplicated or intensified monosyllabic adjectives, and so on. Incidentally, it may be noted that when a monosyllabic adjective precedes a two-syllabled noun accented on the first syllable a false accent, generally implying a heavy unit, results, as in example (25) of Section III. This is often avoided by a transposition of the two words the qualifying word, instead of being given its natural place before the word qualified, is placed after it ; so, instead of saying,

(10.) They've casten him in a deep dungeon,

the ballad of "Young Beichan" says,

(10*a*.) They've casten him in a dungeon deep,

This transposition has been called poetic license; and it probably arose not so much through a desire to differentiate the language of prose and poetry as through an instinctive obedience to rhythmic stress-grouping. In the days when the old ballads were struck to life, word-accent was not so definitely fixed as now, so that many cases of apparently false accent may appear so only by reason of the then indefinite having now become definite. In "Sir Patrick Spens," for instance, the word "sailor" was indifferently accented either on the first or second syllables, or the ballad-maker wilfully contrasted the accent in stanzas 13 and 14 (Allingham) :—

(11.) O whare will I get a gude sailor

and—

(11*a*.) O here am I, a sailor gude

In "Etin the Forester," stanza 16 (Allingham), we have, -

(12.) I'd ask ye something, mither,
An ye wadna angry be.

And in the following stanza,--

(13.) Your cheeks are afttimes weet, mither ;
You're weeping, as I can see.

In (12) "mither" receives the usual accent on the first syllable ; in (13), the unusual accent on the second, *unless the pause indicated by the comma be regarded*, when the usual accent is restored. Similarly in stanza 18 :—

(14.) For I was ance an earl's daughter,
Of noble birth and fame ;

An English reading would give "daughter" the unusual accent on the second syllable ; a Scottish reading--and the ballad as found is Scottish would give it the usual accent on the first syllable, the burr in "earl's" filling the place of the pause which would otherwise separate "earl's" and "daughter." This fascinating subject lies beyond the sphere of prosody, whose duty it is to note the variation of units, not necessarily of words.

5. There is one duple unit, of comparatively rare occurrence, which bears an accent on the first syllable, but neither accent nor stress on the second. There are perhaps four such units in the whole of "Macbeth" :—

(15.) *a.* I hèard/ the oẁl/ *scrèam and ;* the cri/ckets crỳ/.
(Macb. II, ii, 16.)

b. An/gels are bright/ *still, though ;* the bri/ghtest fell/ :
(Macb. IV, iii, 22.)

c. The time has been, my senses would have cool'd
To hèar/a night-/*shrìek, and ;* my fèll/ of hàir/
Would at a dismal treatise rouse and stir
As life were in't : (Macb., V, v, 11.)

d. by the clock 'tis day,
And yèt/ dàrk night// stràngles ; the trà/velling làmp/ :
(Macb. II, iv, 7.)

In the case of *a*, *b*, and *d* most readers would probably make a vocal pause on the vowel preceding the unit in question, when a paused and triple unit would result :—

(15*a*.) *a*. I hèard/ the òwl/   scrèam/ and the cri/ckets crỳ/.
b. Àn/gels are bright/   still/, though the bri/ghtest fèll/:
d. And yet/ dàrk night//   stràn/gles the trà/velling làmp/:

The vocal pause need be but slight to make the scansion that of (15*a*). In example *c* above, "shriek" cannot receive an accent equal to that on "night," or "shriek" would be taken for the verb and not the noun: "night-shriek" is a compound word like "manhood" or "housetop"; and it may perhaps be found that "shriek" would in reading receive no more accent than "and," so that the unit would be an ordinary unstressed unit—

(15*a*.) *c*. To hèar/ a night-/*shriek, and* / my fèll/ of hàir/

It may be, therefore, that there is no need for supposing an accented unstressed unit to exist. It is, however, noted as a possible form. In the following verse it is avoided by an alternative scansion :—

(16.) For the most part, too, they are foolish that are so.
(Ant. & Cleo., III. iii, 34.)

This might be scanned,—

(16*a*.) For the / mòst pàrt//, *too, they* / are fòol/ish that / àre so//.

But this gives six units, including the doubtful one; and a better scansion is,—

(16*b*.) For the mòst/ pàrt, tòo//, they are fòol/ish that / àre sò//.

Section VI.

1. Units composed of a single syllable augmented by a pause are now to be considered—that is, "paused units." The paused unit followed by a triple unit has already been dealt with (paragraph 17 *et seq.* of Section III), and the same preceded by a triple unit (paragraphs 20 and 25 of Section III). To the latter class belong constructions in the old ballads such as the following :—

(1.) *a*. And it hath stricken the Earl Douglas
Ìn/ *at the brèast/   bane/*.
("The Hunting of the Cheviot," fytte ii, st. 12.)

b. And first/ he has hàr/*pit a gràve/   tune/*,
And syne he has harpit a gay ;   ("Glasgerion," st. 7.)

c. She's tà'en/ a càke/ o' the bèst/   brèad/,
A stoùp/ o' the bèst/   wine/,   ("Fair Annie," st. 13.)

d. O give/ me a shive/ o' your brèad/,   lòve/,
O give me a cup o' your wine !
("The Jolly Goshawk," st. 32.)

Here it may, of course, be held that the scansion should be not a triple unit followed by a paused duple, but two duple units, the first ordinary, the second heavy :—

(1*a*.) *c*. She's tà'en/ a càke/ *o' thè/ bèst brèad*//.
d. O give/ me a shive/ *o' yòur/ brèad, lòve*//.

Compare these, however, with lines where such scansion is the natural one, and the difference will be seen :—

(2.) Enòugh/ ye hàe/ *o' gùde/ whèat brèad*//,
And enòugh/ *o' the blùde-/rèd wìne*//;
("Johnnie of Braidisloe," st. 3.)

Moreover, in (1) *b* and *d* the lilt calls for the construction suggested in (1)—the "harpit a grave" is echoed in "harpit a gay," and "o' your bread" is echoed in "o' your wine"; though here again it may be held that a contrast is better than an echo. So long as it is conceded that the scansion in (1) is possible—that is, that the triple unit followed by a paused unit is possible—the point sought by this treatise is gained; individual taste is immaterial. Take the following example:

(3.) Give me leave to set my horne to my mouth,
And to blòw/ blàsts/ thrée′.
("Robin Hood and the Curtall Fryer," line 116.)

If it be held the scansion should be,

(3*a*.) And tò/ blòw blàsts/ thrée′.

the last unit is still a paused unit. Nor is it otherwise should the first unit be considered light and the second heavy—

(3*b*.) And to/ blòw blàst/′ thrèe/.

Very few would, I think, read the line in this way. (See also example (6) *c* following, and remarks thereon.)

2. A unit composed of a pause and a stressed syllable may be found, however, between two ordinary units, all suggestion of the triple construction being absent:—

(4.) *a.* Sè/ven ships/ *loa*/ded weel/′,
Came o'er the sea wi' me; ("Fair Annie," st. 31.)

b. The first/ *stèp*/ the là/dy stèpped/,
She stepped on a stane; ("Lamkin," st. 18.)

c. O whà's/ *blùde*/ is thìs/, he sàys/,
That lieth in my ha'? ("Lamkin," st. 26.)

One source, already referred to, from which constructions may have sprung is the change of two-syllabled to one-syllabled words: many old words took their plural in "es," and were two-syllabled. Terminal "e," too, was once sounded: when the "e" became mute it was in most cases dropped or transformed, and the words originally containing it were robbed of a syllable. In prose this would not be so noticeable; in poetry it was most marked. There is still option in some words, as in those ending in "ed": Keats always gave the "ed" its own syllabic value. Editors—such, for instance, as Newton—clipped words in "ed" where the last syllable was not to receive its full value:

(5.) Nathless, he so *indur'd*, till on the beach
Of that *inflamed* sea he stood, and *call'd*
His legions, Angel forms, who lay *intranc'd*
Thick as autumnal leaves that strow the brooks
In Vallombrosa; where th' Etrurian shades
High over-*arch'd imbow'r*; or *scatter'd* sedge
Afloat, when with fierce winds Orion *arm'd*
Hath *vex'd* the Red Sea coast, whose waves o'er-threw
Busiris and his Memphian chivalry,
While with perfidious hatred they *pursued*
The sojourners of Goshen. (P.L., i, 299 *et seq.*)

Here, in eleven verses, there are eight words in "ed" clipped of a syllable, and in the tenth verse is one which, following the usual rule, should be clipped; one word—"inflamed"—in the second verse receives its full three syllables. Turning to the ballads, the following examples are taken from "A Lytell Geste of Robyn Hode":—

(6.) *a.* Or gỳve/ me *wòun/des* dèep/ and wỳde/,
So to leve me dede. (fytte v, st. 25.)

b. And they beset the knyght's castèll,
The *wàl/les* àll/ abòut/. (fytte vi, st. 2.)

c. Upon àll/ the lòn/des thàt/ I hàve/,
As I/ am a trè/we knỳght/. (fytte vi, st. 4.)

It is clearly seen how, when "woundes" and "walles" lost their second syllables, the paused units were produced; and in the second line of example *c* the paused unit is preceded by a triple unit.

3. The unpaused and paused units are contrasted in—

(7.) *a.* Give me leave to set my fist to my mouth,
And to whù/te whù/es thrèe/.
("Robin Hood and the Curtall Fryer," line 116.)

b. Give me leave to set my horne to my mouth,
And to blòw/ blàsts/ thrèe/. (*Ibid*, line 100.)

The construction of *b* is again seen in—

(8.) *a.* It's up, it's up the Couden bank,
It's doun the Couden brae;
And aye they made the trumpet sound,
It's à'/ fàir/ plày !/
("Katherine Janfarie," st. 15.)

Such units are plentiful enough in modern poetry, and a few examples were given in paragraph 15 of Section III. They may occur at the opening as readily as at the close:—

(9.) *a.* Hère/ grèat/ sòuls/. / in a plè/nitùde/ of vì/sion,
Plànned/ high/ dèeds/ / as immòr/tal as/ the sùn/;
(*Lord Bowen*, "Shadow Land.")

b. Sà/vage Ì/ was si/tting in/ my hòuse/, làte/, lòne/:
Drèa/ry, / wèa/ry with/ the lòng/ dày's/ work/:
Hèad/ of mè/, hèart/ of mè/, stù/pid as/ a stòne/:
Tòngue-/ tied/ nòw/, nòw/ blasphèm/ing like/ a Tùrk/;
(*Browning*, "Epilogue: The Householder," opening.)

4. In blank verse this unit rarely occurs unless preceded or succeeded by a triple unit, as discussed in paragraph 20 *et seq.* of Section III. Did it occur between normal units, the verse would lose a *syllable*. There would, of course, still be the compensation of the *pause*, but the pause was disregarded in the poetry of numbers, so that in "Paradise Lost" and "Paradise Regained" the paused unit in normal surroundings is practically non-existent. It may, however, be frequently found in Shakspeare:—

(10.) *a.* My plenteous joys,
Wanton in fulness, seek to hide themselves
In dròps/ of sòr/row. Sòns/, *kins*/men, thànes/,
And you whose places are the nearest, (Macb., I, iv, 35.)

b. Whàt/ should be spò/ken hère/, *whère*/our fàte/,
Hid in an auger-hole, may rush, and seize us?
(Macb., II, iii, 127.)

This unit may be called the "heavy paused unit."

5. Much more common is the unit composed of an unaccented syllable *followed* by a pause. It is the normal fourth unit of verse of the Nibelungen type, as in—

(11.) The lòve/ that I/ hae chò/*sen*, /
I'll thère/with bè/ contènt/;
The sàut/ sea sàll/ be frò/*zen* /
Befòre/ that I/ repènt/.
Rèpent/ it sàll/ I nè/*ver* /
Until/ the dày/I dèe/;
But the Làw/*lands* /o' Hol/*land* /
Hae twìnn'd/ my love/ and mè/.
("The Lowlands o' Holland," st. 1.)

The pause is perfectly evident to the ear when reading aloud, more especially when a verse containing the pause is followed by one from which it is absent, as in Macaulay's "Horatius":—

(12.) Then òut/ spake bràve/ Horà/*tius*, /
The càp/tain of/ the gàte/:
To è/very màn/ upòn/ this èarth/
Death còm/eth soon/ or làte/.

The great German epic poem "Die Nibelungen Noth" is composed almost entirely of verses containing this paused unit at each half-line end; but its double occurrence as in the last verse of (11) is rare. Burns is the only modern poet who has used it at all consistently, and then only as the conclusion of a particular stanza:—

(13.) While winds frae aff Ben-Lomond blaw,
And bar the doors wi' drivin' snaw,
And hing us owre the ingle,
I set me down to pass the time,
And spin a verse or twa o' rhyme,
In hamely, westlin jingle:
While frosty winds blaw in the drift,
Ben to the chimla lug,
I grudge a wee the great folks' gift,
That live sae bien an' snug:
I tènt/ *less*, /and wànt/ *less* /
Their ròo/my fì/re side/;
But hàn/*ker*, /and càn/*ker*, /
To sèe/ their cùr/sed prìde/.]
("Epistle to Davie.")

This stanza form is thought to have been invented by the Scottish poet Alexander Montgomerie, born about 1540.

6. The peculiarity of this unit is that it is the *stressed* syllable has been dropped, the unstressed syllable remaining; so that this unit might almost be regarded as a still lighter form of the one discussed in paragraph 5 of Section V. The actuality of the latter, however, is dubitable; whereas the existence of the former is quite beyond doubt. It may be called the "light paused unit."

7. The light paused unit may be found at the verse-end of blank verse, but this is unusual:—

(14.) Up, up, and see
The grèat/ doom's ì/mage ! Màl/colm ! Bàn/*quo !*
As from your graves rise up, and walk like sprites,
To countenance this horror. (Macb., II, iii, 83.)

In this instance perhaps a better scansion might be,—

(14*a*.) The grèat/ doom's ì/mage ! / Màl/colm ! Bàn/(*quo !*)

where a pause theoretically taking the second half of the third and the former first half of the fourth units divides the metaphorical speech from the call. It is reasonable to suppose such a division: it would argue the taking of a deep breath to make the calls the louder. The result of the scansion (14*a*) is to make the light paused unit the third unit instead of the fifth, to make the fourth a heavy paused unit, and to give the fifth a feminine ending; yet perhaps the extraordinary occurrence described in the verse warrants the extraordinary variety in the metre. The pause will probably not be equal to a full unit in reading; there is nothing tangible to enforce such full value being given, but, as in a physical organ, the fundamental structure is the same if the unit be vigorous or in a state of atrophy. Another instance of a silent unit may be cited: —

(15.) went it not so?
To the sèlf-/sàme tìme// and wòrds/. /Whò's hère ?//
(Macb., I, iii, 88.)

Again the pause after "words" seems logical. Banquo makes a slight pause before accosting Ross and Angus, who enter at that moment with the King's message to Macbeth. Of course, these silent units cannot be proven in the rugged metre of dramatic verse: it is enough to suggest their possibility. Their probability may be surmised when it is known that primarily all Alexandrine verse was divided into two halves by a silent unit this will be dealt with in the chapter on verse-lengths.

8. Within the verse the light paused unit is not so unusual as at the verse-end:—

(16.) *a.* The raven himself is hoarse
That croaks/ the fà/tal èn/*trance* /of Dùn/(can)
Under my battlements. (Macb., I, v, 40.)

b. Haply you shall not see me more; or if,
A màn/gled shà/*dow:* / perchànce/ to-mòr/(row)
You'll serve another master. (Ant. & Cleo., IV, ii, 27.)

The construction is quite different in verses like—

(17.) *a.* Yet here, Laer*tes!* *Aboard*, aboard, for shame!
(Hamlet, I, iii, 55.)

b. Two nights together had those gentlemen . . .
Been thus encoun*ter'd*. *A fi*gure like your father
(Hamlet, I, ii, 199.)

Here triple units are divided by pauses, the scansion being—

(17*a.*) *a.* Yet hère/, Laèr/*tes!* *Abòard*/, abòard/, for shàme!/

b. Been thùs/ encoun/*ter'd*. *A fi*/gure like/ your fà/(ther).

Were a paused light unit supposed, the scansion would be —

(17*b.*) *a.* Yet hère/, Laèr/tes! /Abòard/, abòard/, for shàme!/
b. Been thùs/ encòun/ter'd. /A fi/gure like your fà/(ther)

—when the verses would contain six units instead of the normal five. The same applies to ballad-measures. For instance,

(18.) I fear thy kisses, gentle maiden,

differs from

(18*a.*) Then out spake bold Horatius,

in this: the former contains not only the full four units of the ballad half-line, but an additional syllable also; the latter contains a syllable *less* than the full four units:—

(18*b.*) I fèar/ thy kis/ses, gèn/tle mai/(den,)
Then oùt/ spake bòld/ Horà/tius, /

The result is that whereas in the full verse of (18*a*) a paused light unit will be found, a triple unit will be found in the full verse of (18) :- -

(19.) *a.* I fèar/ thy kis/ses gèn/tle mai/*den, thou nèe*/dest nòt/ fear mine/;
b. Then òut/ spake bòld Horà/*tius,* /the càp/tain of/ the gàte/:

9. This extra syllable, like the "den" of "maiden" in (18), may occur at the end of heroic and blank verses, or at the end of ballad verses, when such verses are said to have a feminine or weak ending. It is owing to the great preponderance of words of one syllable in the English language that feminine-ended verses are not the normal ones, since words of more than one syllable tend to take the accent on the last syllable but one. With the view to ascertaining approximately the proportion of one-syllabled words to words of more than one syllable occurring at the ends of verses, the first five hundred verses of various poems have been taken, and their endings tabulated. Thus, of "Paradise Lost" the first five hundred verses of Book I have been analysed, the end words only being taken; the first five hundred of Act III, scene i, of Swinburne's "Chastelard"; of "Endymion," &c.. as follows :–

TABLE I.

	End-words containing					Feminine Ends.		Total.
	1 Syll.	2 Syll.	3 Syll.	4 Syll.	5 Syll.	Single.	Double.	
"Paradise Lost"	378	79	24	7	..	12	..	500
"Chastelard," III. i ..	444	23	18	1	..	14	..	500
"Endymion"	378	42	36	9	1	34	..	500
"Hyperion"	414	33	34	7	1	11	..	500
"Two Gent. Ver.," II, iv ..	299	55	44	10	3	87	2	500
"Sonnets" of Shakspeare ..	348	65	26	5	..	56	..	500
Totals	2,261	297	182	39	5	214	2	3,000

Again the same poems have been taken and the first five hundred words analysed, including all words in the body as well as at the end of the verses, with the following result :- –

TABLE II.

	Words containing					Total.
	1 Syll.	2 Syll.	3 Syll.	4 Syll.	5 Syll.	
"Paradise Lost"	365	97	30	8	..	500
"Chastelard," III, i	453	42	5	..	..	500
"Endymion"	363	115	19	3	..	500
"Hyperion"	387	92	20	1	..	500
"Two Gent. Ver." II, iv	389	82	23	4	2	500
"Sonnets"	382	94	20	4	..	500
Totals	2,339	522	117	20	2	3,000

These tables show decisively the great preponderance of one-syllabled words not only at the line-ends, but also in the body of the verse. The great disparity between the number of two-syllabled words at the verse-ends and in the body of the verse is easily accounted for when it is remembered that by far the greater number of such words is accented on the first syllable, and their use at the line-ends would make feminine endings, of which there are in the above examples only 216 in 3,000 verses.

10. Most one-syllabled words may be accented or not, according to context. This means that when two such words come together, one, both, either, or neither may bear the accent. In two-syllabled words, however, it is usual that either the first or the second syllable bears the accent: the words " heavy," " open," " settle," are always accented on the first syllable; the words " amiss," " repeal," " betake," usually on the second syllable. These words with fixed accent, then, cannot in poetry naturally be used in a place where the stress would fall on the unaccented syllable, without either the stress being suppressed, or the word receiving both natural accent and rhythmic stress (see paragraph 24 of Section III). It is different with the one-syllabled words: no two of these come together invariably in any certain sequence, for which reason the stress may fall on either or neither—as " I àm the màn," or " Ì am hè," or " I am nòt of the clàn."

11. Before deciding on the classification of feminine endings it will be as well to examine them a little more closely. As stress is a result of breath-action, the stress of any syllable must be on the vowel—the breath-letter. Where the syllable does not end with a vowel, then, it is evident the sound of it is prolonged beyond the vowel, and in scansion by stress-units, where the stress is the bound of the unit, that part of the syllable following the vowel occupies part of the time of the following unit. In the following passage the ordinary scansion is denoted: -

(20.) Stop ùp/ the accèss/ and pàs/sage to/ remòrse/,
That nò/ compùnc/tious v /sitings/ of nà/(ture)
Shàke/ my fèll pùr//pose, nor/ kèep pèace// betwèen/
The effèct/ and ìt !/ Còme/ to my wò/man's brèasts/,
And tàke/ my mìlk/ for gàll/, you mùr/dering mìn/(isters.)
Wherèv/er in/ your sìght/less sùb/stances/
You wàit /on nàture's mìs/chief ! Còme/, thick night//,
And pàll/ thee in/ the dùn/nest smòke/ of hèll/,
That mỳ/ kèen knife// sèe/ not the wòund/ it màkes/,
Nor hèaven/ pèep thròugh// the blàn/ket of/ the dàrk/,
To crỳ/ " Hòld, hòld !" // (Mach., I, v, 45.)

Now, a syllable is composed of one sound when its vowel is followed by an open consonant, but of two sounds if followed by a closed consonant. These two kinds of consonants are classified as under:—

TABLE III.

Open Consonants.		Closed Consonants.	
Breathed.	Sonant.	Dulled.	Explosive.
f	v	b	p
..	l	..	c
..	m	j	ch
..	n	g	k
..	r	d	t
s	z	..	h
sh	..	q (kw)	..
th (think)	th (thine)	..	x(ks)
wh	..		
..	w		

Thus, the word "ruff" is all spoken on the breath; it is one sound: but "rut" has two distinct sounds; there is a pause between the completion of the vowel sound and the completion of the consonantal sound—that is, there is a stoppage of breath in the midst of the syllable. In the open consonants there is a free and uninterrupted passage of breath; in the closed consonants there is a momentary stoppage. Thus it is that two parts of one word may be more widely separated than two distinct words. In the word "obey," for instance, there is a greater pause between the "o" and the "bey" than between the "I" and "am" of "I am"; hence the common colloquial corruption of the latter to "I'm." This easy gliding from vowel to vowel was doubtless also the reason for the prosodic colloquialism of "clipping" referred to in paragraph 17 of Section III. In scansion by stress-units, then, any closed consonant following a stress will naturally fall into the following unit. It must be remembered, at the same time, that a doubled consonant like the "bb" in "rubbing" does not indicate a doubled consonantal sound, but a shortened vowel; and the word should not, therefore, be divided "rùb/bing," but "rù/bbing." Doubled open consonants may be thus divided if desired, as their sound is continuous, though it receives no stress. The better scansion of (20) would therefore be,—

(21.) Stop ù/p the accè/ss and pà/ssage to/ remo/(rse,) 1
That nò/ compù/nctious vi/sitings/ of nà/(ture) 2
Shà/ke my fèll pù//rpose, nor/ kèep pèace// betwèe/(n) 3
The effè/ct and ì/t! Cò/me to my wò/man's brèa/(sts,) 4
And tà/ke my mì/lk for gà/ll, you mù/rdering mi/(nisters,) 5
Wherè/ver in/ your sìgh/tless sù/bstances/ 6
You wà/it on nà/ture's mì/schief! Cò/me, thick nìgh//(t,) 7
And pà/ll thee in/ the dù/nnest smò/ke of hè/(ll,) 8
That mỳ/ kèen knì//fe sèe/ not the woù/nd it mà/(kes,) 9
Nor hèa/ven pèep throùgh// the blà/nket of/ the dà/(rk,) 10
To crỳ/ "Hòld, hò//ld!"

Naturally, odd consonants may as readily fall beyond the last unit as outside the first or any other, and it appears to be only a matter of degree how many consonants thus fall beyond the unit. There may even be one or two vowels amongst those consonants, making one or two syllables. When such vowels occur, the feminine and double feminine endings result; and it was seen by Table I above that in 3,000 verses there were only 214 feminine and 2 double feminine endings. In the above quotation from "Macbeth," in verses 1, 4, 6, 7, 9, 10 there is only breathed or hissed sound falling beyond the last unit; in verses 3 and 8 there is the sustained sound of liquid consonants; in verse 2 there is a vocal vowel, "u," making another syllable, "ture," resulting in a feminine ending; and in verse 5 there are two vocal vowels, "i" and "e," making two syllables, resulting in a double feminine ending. The difference between these various verse-endings is largely one of degree only: as regards duration of sound, it will probably be admitted readily that the word "nature," ending verse 2, occupies less time in utterance than the word "breasts," ending verse 4; and of the parts falling beyond the unit it will as probably be admitted that "ture" occupies less time than "sts," for in the former there is but one continuous sound, whereas in the latter there are two. Whilst, therefore, "ture" is syntactically a syllable in itself, and "sts" is only part of a syllable, prosodically each occupies part of a time-space lying beyond the last unit of the verse. Again, were the word ending verse 5 "minsters" instead of "ministers," the time-value of "sters" would be little more than that of "sts," and "min" being of less time-value than "brea" the total time-value of the two words would practically be equal. Indeed, repeating the two words "breasts" and "minsters," their difference, whilst appreciable, is very inconsiderable; and the insertion of the short "i," making "minsters" "ministers," lengthens the word very little indeed, whilst it makes the articulation easier. The whole contention is this: that the extra syllables of feminine and double feminine endings are often of very little more time-value than the consonantal endings of one-syllabled end words. Two examples of double feminine endings follow:—

(22.) *a.* he fishes, drinks and wastes
The làmp/ of night/ in rè/vel: is nòt/ more màn/(like)
Than Clè/opà/tra, nor / the quèen/ of Ptò/(*lemy*)
More womanly than he. (Ant. & Cleo., I, iv, 6.)
b. For sò/litùde/ sometimes/ is bèst/ soci/(*ety*,)
And short retirement urges sweet return. (P.L., ix, 249.)

Words with light endings, like "society," &c., are usually given a fictitious stress—that is, they occupy the position where a stress would fall were it not suppressed:—

(23.) *a.* They swim in mirth, and fancy that they feel
Divi/*nity* / within/ them brèe/ding wings/,
Wherewith to scorn the earth: (P.L., ix, 1010.)
b. Sin/ and her shà/dow Dèath/, and Mi/sery /
Death's harbinger. (P.L., ix, 12.)

In the following, "misery" appears as a three-syllabled word accented in the usual way on the first syllable:—

(24.) Yet well, if here would end
The mi/sery; Ì/ desèrv'd/ it, and / would bèar/
My own deservings; (P.L., x, 726.)

A comparison of "society" in two different positions is of interest: first as quoted in (22) *b*, where it occupies the last unit and and forms a double feminine; then where it occupies two full units, no feminine resulting:—

(25.) *a.* For sò/litùde/ sometimes/ is bèst/ *socì*/(*ety*,)
b. Amòng/ unè/quals, whàt/ *socì*/*ety* /
Can sort, what harmony or true delight? (P.L., viii, 383.)

It will be noted that the double feminines all contain very short vowels; this, too, obtains, as a rule, in the single feminines, examples like the following being comparatively uncommon:—

(26.) *a.* You may
Convey your pleasures in a spacious plenty,
And yèt/ seem còld/, the time/ you mày/ so *hòod*/(*wink*:)
(Macb., IV, iii, 72.)
b. Now mi/nutely / revòlts/ upbraid/ his *fàith*-/(*breach*;)

12. The question now is, in what way do these feminine endings fall within the metrical scheme? It is commonly held that they occupy part of the rhythmic pause that usually divides the verses of blank verse one from another. It is admitted that metrical pauses are of almost universal occurrence in heroic, or five-stressed rimed verse, but it is probable that the rime augmented the pause, if it did not create it; and hence it is that much heroic verse—Pope's, for example—is a series of epigrammatic couplets. It is, however, contended that the discarding of the rime in blank verse was not only a rejection of the "jingling sound of like endings," or an emancipation from restriction, since to no true poet is rime a restriction, but also a step towards the rejection of rhythmic pause in favour of the

syntactic pause: it was felt the natural expression of thought demanded the overflow—that is, the running-on of the thought from one verse into another, and the rejection of the coterminousness of the thought with the verse. There are many who still maintain that there should be at least a slight pause after *every* verse, even of blank verse, to insure the preservation of the rhythm; but surely the poets themselves deny this in a most emphatic manner by creating such verses as,

(27.) *a.* as that sole bird,
When to inshrine his reliques *in the sun's*
Bright temple, to Egyptian Thebes he flies. (P.L., v, 273.)
b. Mark Antony is every hour *in Rome*
Expected: since he went from Egypt 'tis
A space for farther travel. (Ant. & Cleo., II, i, 29, 30.)

Blank verse may, indeed, be considered as the link between prose and lyric rimed poetry. It is not to be considered as composed of so-many distinct five-stressed verses, but of *groups* of verses. A most casual reading of Shakspeare or Milton, or indeed any poet, will show this at once. In Pope, couplets whose thought is complete—even single verses—may be detached by the score; in blank verse the jewels of thought will often include many verses, beginning and ending at any point within the verse.

13. Considering blank verse as a composite whole, then, and not as a collection of individual and self-sufficient verses, the place of the feminine endings is shown more clearly—they form part of the first unit of the verse following. This is often self-evident in the case of single feminine endings:—

(28.) but who here
Will envy whom the highest plàce/ expò/(*ses*)
Forè/most to stànd/ against the Thunderer's aim
(P.L., ii, 27.)

It is evident in such examples that the feminine ending completes the first unit of the following verse, taking the place of the pause which would have divided the two verses had the first ended with a stress. In the following examples the verse after the feminine ending opens with an already complete unit:—

(29.) *a.* by command
Of sovran pow'r, with àw/ful cè/remò/(*ny*)
And trùm/pet's sòund/, (P.L., i, 753.)
b. since fàte/ inè/vita/(*ble*)
Subdùes/ us, and / omnipotent decree, (P.L., ii, 197.)

No pause, or a very slight pause only, separates the feminine ending from the following verse. The result is, the first unit of the verse following the feminine ending is triple. Example (29) *a* could as well be written,

(29*a*.) With àw/ful cè/remò/ny and trùm/pet's sòund/,

when an ordinary verse results. It may be conceded that this may be the case with a single feminine ending, but not with a double feminine. Example (22) *a* may be written,

(30.) Is nòt/ more màn/*like than Clè*/opà/tra, nor/
The quèen/ of Ptò/*lemy more wò*/manly/ than hè/.

when both single and double feminine endings by being incorporated in the verse produce triple and quadruple units. The resulting quadruple unit as above does not in any way differ from the undoubted quadruple units exampled in (4) of Section IV, and there would, therefore, appear to be no objection to the suggestion that a feminine ending is in reality part of the following unit, lying within, and not without, the metrical scheme of units.

14. In ballad or lyric poetry there is less difficulty in showing that the feminine ending forms part of a unit; for the full verse, containing six, seven, or eight stresses, is usually divided into two parts; and it is at the point of division, after the first half-verse, that the feminine ending most frequently appears. One example was quoted at the end of paragraph 8 of this section:

(31.) I fèar/ thy kìs/ses gèn/tle mài/(den.)
Thou nèe/dest nòt/ fear mìne/;

It is evident, when this verse is printed at length, that the feminine does no more than form a triple unit:—

(31*a*.) I fèar/ thy kìs/ses gèn/tle mài/den, thou nèe/dest nòt/ fear mìne/;

The second line often begins abruptly, or with a stressed syllable, when there is not the slightest doubt that the feminine forms part of a unit:—

(32.) *a*. "Nòw/ and thou lèse/ thy lònde "/, sayd Rò/(byn,)
"Whàt/ shall fàll/ of thèe ? "/
("A Lytell Geste of Robyn Hode," fytte i, st. 55.)

b. Fair Màr/garet sàt/ in her bò/wer win-/(dow)
Còm/bing her yèl/low hair/;
("Fair Margaret's Misfortunes," st. 2.)

Printing these lines as their full verses, we have,

(32*a*.) *a*. "Nòw/ and thou lèse/ thy lònde "/, sayd Rò/*byn*, "*whàt/* shall fàll/ of thèe ? "/

b. Fair Màr/garet sàt/ in her bò/wer wìn/*dow còm/*bing her yèl/low hàir/ ;

Can there be the least doubt that the italicised units are ordinary duple units? Nor is there more doubt when the unit appears as triple instead of duple, especially when another triple unit occurs in the verse:—

(33.) *a*. They làn/ded nèar/ the Èarl/ Màr's càs//(tle,)
Took shèl/ter in èv/ery trèe/.
("Earl Mar's Daughter," st. 30.)

b. "O whàre/ will I gèt/ a skèe/ly skì/(pper)
To sàil/ this new shìp/o' mìne ? "/
("Sir Patrick Spens," st. 1.)

(33*a*.) *a*. They làn/ded nèar/ the Èarl/ Màr's càs//*tle, took shèl/ter in èv*/ery trèe/.
b. O whàre/ *will I gèt/* a skèe/ly skì/*pper to sàil/ this new shìp/* o' mìne ? "/

It may, of course, be objected that the word causing the feminine should be pronounced with the second syllable accented—"castèl," "skippèr." The same objection may be urged against each of the examples in (32); but, granting this fictitious accentuation in (32), the resulting pause between the two lines will at once indicate where a syllable has been dropped—

(34.) Fair Màr/garet sàt/ in her bò/wer windòw/ còm/bing her yèl/low hàir/;

—and is it not evident beyond all doubt that the syllable has been dropped from the fifth unit? Where two lines, as in these examples, form one unbroken verse, it is surely immaterial, the rhythm being continuous, whether the first syllable of the fifth unit be attached to the end of the first line or the beginning of the second. It is merely a matter of printing: read the full verse aloud, and all anomaly disappears. So, too, with the examples in (33), where triple units are produced. Here no pause breaks the rhythm if the fictitious accentuation be adopted, but a most noticeable difference in rhythm is produced. The two readings may be contrasted:—

(35.) *a*. O whàre/ *will I gèt/* a skèe/ly skì/*pper to sàil/ this new shìp/* o' mine ?/
b. O whàre/ *will I gèt/* a skèe/*ly skippèr/* to sàil/ *this new shìp/* o' mine ?/

It is self-evident that by the transference of a syllable from the fifth to the fourth unit a difference has been made in those units. In *b*, the unit

"/ly skippèr/," containing three syllables, is uttered in the same time as the unit in *a*, "/ly ski/," containing only two syllables; and similarly the unit "/pper to sàil/" in *a* occupies no more time in utterance than "/to sàil/" in *b*. The time-value of no unit is altered, merely the syllabic value; and again, in reading aloud, it is immaterial whether the fourth or the fifth unit be the one of three syllables.

15. When the feminine ending follows the second line, or the verse-end, there is no question, so far as six- and seven stressed verse is concerned, that it occupies the "silent unit"- the unit in which the breath is usually taken:—

(36.) "O fàre/ ye wèel/, my là/dy dèar!/
And pùt/ aside/ your sòr/(*row*;) /
For if/ I gàe/, I'll sùne/ retùrn/
Frae the bòn/ny bànks/ o' Yàr/(*row*.") /
("The Banks o' Yarrow," st. 1.)

There is a peculiar custom, most common in Scottish ballads, of affixing an "O" to the end of a ballad verse; and it is often doubtful whether a feminine ending only is intended, or it is wished to prolong the ballad verse of seven stresses to a romance verse of eight stresses. In the following a feminine ending is doubtless intended:

(37.) She kiss'd/ his chèek/, she kaim'd/ his hàir/,
As òft/ she'd dòne/ befòre/, (*O*;) /
She bèl/ted hìm/ wi' hìs/ gùde brànd//,
And hè's/ awà'/ to Yàr/(row.) /
("The Banks o' Yarrow," st. 4.)

In the following, however, it would seem that it was intended to eke out the ballad verse, dwelling on the "school" and "weel," and so filling the eighth unit with a vocal pause and "O":

(38.) My dòch/ter can nàe/ther rèad/ nor wrìte/,
She nè'er/ was brocht ùp/ at schòol/, O/;
But wèel/ can she milk/ baith còw/ and èwe/,
And màk/ a kè/bbuck wèel/, O/.
("The Laird o' Drum," st. 7.)

In all examples such as (36) the syllable of the feminine ending is usually very short, and might be regarded as mere prolongation of sound after the last stressed vowel. A theoretically perfectly ending unit should end with the stress, as in

(39.) O mickle was the gude red wine
In silver cups/ did *flow*/;
But aye she drank to Lamington,
And fain with him/ would *gò*/.
("Katherine Janfarie," st. 11.)

Almost as perfect is the unit ending in an open consonant, as in -

(40.) There was a may, a weel-far'd may,
Lived high up in/ yon *glen*/:
Her name was Katherine Janfarie,
She was courted by mon/y *mèn*/.
("Katherine Janfarie," st. 1.)

A theoretically imperfect unit is one whose stressed syllable ends with a closed consonant—that is, a syllable requiring at least two distinct sounds for its utterance—as in—

(41.) They turned him in fair Janet's arms
Like ice on fro/zen *làke*/;
They turned him into a burning fire,
An adder, and/ a snàke/. ("Tamlane," st. 35.)

In "Katherine Janfarie," out of twenty-two stanzas, seven stanzas have verse-endings in vowels, seven have verse-endings in open consonants, eight in closed consonants, and one in a feminine. The following table will give an approximate idea of the proportion of these verse-endings :—

TABLE IV.

	Stanzas whose Verses end in				Total.
	Vowel.	Open Consonant.	Closed Consonant.	Feminine.	
"Earl Mar's Daughter" ..	26	7	3	..	36
"Edom o' Gordon"	18	10	5	..	33
"Sir Patrick Spens"	6	10	6	..	22
"Fair Annie"	9	14	6	2	31
"Childe Maurice"	10	14	2	..	26
"The Jolly Goshawk" ..	14	16	5	..	35
"Katherine Janfarie"	7	6	3	1	17
"Fair Annie of Lochroyan" ..	10	15	11	..	36
"Etin the Forester"	28	15	2	..	45
"May Colvin"	12	2	2	..	16
"The Ship o' the Fiend" ..	14	6	4	..	24
"Lamkin"	8	18	3	..	29
"Burd Ellen"	14	10	4	1	29
"Glasgerion"	8	15	3	..	26
"Tamlane"	17	17	7	..	41
Totals	201	175	66	4	446

This gives the high average of 376 units ending with a vowel or open consonant, as against 70 units ending with a closed consonant or a feminine, in 446 units. The tendency appears in favour of units ending on the stressed vowel, but a much more extended table would have to be prepared before an absolutely definite statement could be made. It has already been noted that the time-duration of most feminine endings is less than the mere consonantal ending of many syllables, as in example (21) of this section, where it is contended that the two-syllabled word "nature" takes less time in enunciation than the one-syllabled word "breasts," yet the former is said to make a feminine, the latter an ordinary ending.

16. Bearing in mind the last statement of the preceding section, it may perhaps be less difficult to account for the apparent anomaly of a feminine ending following the last unit of a romance verse that is, a ballad verse of eight stresses. The following is an example :

(42.) Go fètch/ to mè/ a pint/ o' wìne/,
And fill/ it in/ a sil/ver tàs/(*sic*,)
That Ì/ may drink/ befòre/ I gò/
A sèr/vice to/ my bòn/nie làs/(*sic !*)
(*Burns*, "The Silver Tassie," part st. 1.)

In each verse but the last it may, of course, be held that a triple unit is produced, as in the middle of the verses quoted in (33*a*) above ; but in this instance it means, not that a triple unit occurs in the middle of a verse, but at the *beginning* of the following verse. Considering that the rhythmic pause at the end of romance verse may be taken as part of the first unit, that first unit may well be held to be equal to a triple unit, easily capable of containing the small feminine syllable. In the last verse, however, there is no spare unit for the feminine ending. In ballad verse of seven stresses there is the silent unit; in romance of eight stresses there is no such unit, and the feminine ending must be held, prosodically, to be the mere continuation of sound from the last unit.

17. The distinct pause often discernible after a feminine ending need be no objection to its forming part of a triple unit, as triple units are often divided by a pause (see paragraph 1 of Section IV).

Section VII.

1. It remains only to summarise and tabulate the various kinds of units. A unit, or stress-unit, is the interval of time elapsing between two wave-beats of rhythm. It is in itself inaudible, and its presence is manifested by stressed sound floating upon its waves. Such sound may be inarticulate, or articulate but not understood, yet it is rhythmic. Poetry is emotional speech floating upon a regular rhythm tangible syllabic utterance floating upon intangible rhythmic waves or pulsations: the natural accents of speech coinciding with the pulsations of the rhythm give the stresses, or beats. These stresses are divided by approximately equal periods of time, and the time-period from stress to stress constitutes the stress-unit. The variation in units is caused by their syllabic burden; the units themselves vary only in their "tempo." A unit may be altogether silent, or may contain from one to five syllables; the number is not arbitrary, nor fixed. The unit, which is taken as ending with its stress, may have that stress suppressed, or may have an accented syllable preceding it in addition to the accented syllable coinciding with the stress. The syllables in a unit may lie together, or may be divided by a pause. The following are the units found in British verse, with names proposed for them, old names rejected being given in brackets:—

Ordinary duple unit	- ‿ /	(Iamb.)
Light ,, ...	‿ - /	(Pyrrhic.)
Heavy ,, ...	- //	(Spondee.)
Divided ordinary duple unit ..	- /	
,, light ,, ..	- /	
,, heavy ,, ..	//	
Paused light ,, ..	‿ /	or Nibelungen.
,, heavy ,, ..	/	or Abrupt.
Ordinary triple unit	‿ ‿ - /	(Anapest.)
Heavy ,, ...	‿ - - //	(Bacchius.)
Divided ,, ...	{ ‿ ‿ - / { ‿ ‿ - /	
Ordinary quadruple unit ..	‿ ‿ ‿ — /	(Fourth paeon.)
Heavy ,, ..	‿ — ‿ — //	(Diiamb.)
Divided heavy quadruple unit ..	— — //	
Quintuple unit	‿ ‿ ‿ ‿ — /	(Fourth parapaeon.)
Feminine ending	/ (‿)	
Double feminine ending	/ (‿ ‿)	
[Doubtful unit, reversed duple. ..	— ‿ /	]

Whilst this is a full table of observed unit-variation, such a large number of units is quite unnecessary except for prosodic demands. For ordinary purposes the following are ample :—

1. Ordinary duple unit.
2. Light duple unit.
3. Heavy duple unit.
4. Paused light duple unit.
5. ,, heavy duple unit.
6. Ordinary triple unit.
7. ,, quadruple unit.

Units 4 and 5 most commonly occur at the end and beginning of lines respectively : 4 is the unaccented last syllable of the Nibelungen half-verse ; 5 is the opening syllable of trochaic or dactylic measures, which, from opening on a stressed syllable, may be called "abrupt." Different readers will give different values to pauses, accents, and stresses ; nor can it be said of any particular reading that it is right, nor of another that it is wrong—the one may have been generally accepted five years ago, the other may be accepted five years hence. Poetry, as a living growth, constantly changes —discarding some variations, adopting others, but always showing obedience to fundamental laws. The task of the prosodist is to define the fundamental laws, noting variations of structure as a guide to the discernment of these laws.

2. The law of verse-length will be discussed in a separate chapter. The chief law of the "stress-unit" appears to be comparative temporal uniformity, with almost infinite syllabic variation. The temporal division of verse is of the first importance ; stresses are of second importance, as indicators of the division ; syllables are of third importance ; thought is of fourth importance. This is from a prosodic point of view ; from an æsthetic standpoint the order must be exactly reversed.

3. A possible origin of the stress-unit was suggested in a paper on "Metre." printed in vol. xl of the Transactions.

Art. LIV.—*The Physiography of Wellington Harbour.*

By J. M. Bell.

[*Read before the Wellington Philosophical Society, 6th October, 1909.*]

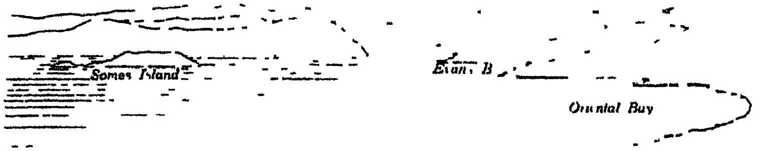
Introduction.

The site of the capital of New Zealand was chosen primarily because of the existence of a spacious land-locked harbour, with good anchorage for ships, in a convenient part of the Dominion's land area.

Owing to its harbour, to its central position, and its choice as the country's capital, Wellington's commercial supremacy in the Dominion seems assured. For these economic reasons, if not from purely scientific interest, it is well to understand the effect of the various forces which have acted together to form Wellington's harbour, generally known as Port Nicholson.

The Harbour To-day.

The harbour is a fine sheet of water, about nine miles long by five miles wide, land-locked save at the comparatively narrow entrance, only 88 chains wide. A number of islets, and two small islands known as Somes Island and Ward Island, appear on its surface; while several shoals either almost or totally below its surface render navigation somewhat difficult in places.



View from Kelburne Kiosk.

High hills almost completely surround the harbour, rising in general in steep slopes from the water's edge. There are, however, several fair-sized areas and small patches of level or gradually sloping land close to the edge of the harbour. By far the largest of these is that which forms the relatively wide valley of the Hutt River, extending north-eastwards from the north-eastern end of the harbour. This plain has a width of nearly two miles and a half near the harbour, and gradually narrows as it extends inland.

Westward from the narrow channel connecting Port Nicholson with the open sea is a low range of hills, which may for convenience sake be called the Seatoun Hills, owing to the settlement of that name at their eastern base. These are connected with the Kilbirnie Hills, to the west, by a narrow sand isthmus between Evans and Lyall Bays.

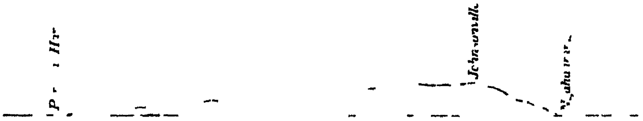
The Kilbirnie Hills attain their maximum altitude in Mount Victoria, which rises some 648 ft. above the sea. To their westward is the low and elatively flat land on which the City of Wellington stands, having a slope on the northern side to Lambton Harbour and on the southern side to Island Bay.

Westward of the city rise the Karori Hills. These are partially separated by the Karori Valley from the main range of hills extending north-eastwards along the edge of the harbour and bordering the Hutt Valley to the westward.

A view from any prominent position in the hills around Port Nicholson discloses an elevated country stretching in all directions, broken by narrow valleys and deep ravines. If this elevated country be viewed from a point on the eastern side of the harbour, one is struck with the general uniformity in height attained by the crests of the various hills on the west side. Since this even skyline is quite independent of the structure of the country rocks (consisting of highly folded and shattered argillites and grauwackes), it apparently exhibits an elevated plain of erosion, or peneplain.

When the country to the east of the harbour is viewed from the west, at least three, and possibly more, ridges of hills are evident. In each of these ridges the hills seem to rise to an approximately uniform altitude, though there is a marked difference in the general height of the several ridges. Naturally, the highest ridge visible is that farthest east. Below this inner one the two other conspicuous even-crested ridges stand out in step-like blocks. Apparently the crests of all these ridges represent various levels of the old peneplained surface so well seen to the west of the harbour.

From a high point on this western land the crests of the hills, though in general of uniform height, seem gradually to descend in altitude towards Porirua.



SECTION, PORIRUA TO NGAHAURANGA.

GEOLOGICAL HISTORY.

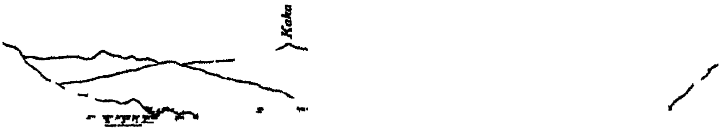
It will be interesting, now that we know what the harbour and the surrounding country are like to-day, to recapitulate the changes which have taken place in this part of the world since the very earliest geological periods.

In late Palæozoic or early Mesozoic times the sea rolled over much of the area now occupied by the present land-surface of New Zealand, and in the locality of Wellington sands and silts were being deposited on the edge of a land area within that sea. It is impossible to state exactly where that ancient land stood, or how far it extended; but since we find that the rocks now exposed around Wellington consist of a great series of argillites and grauwackes, which were originally silts and sands or deposits usually laid down close to a land-margin, it may be presumed that the deposition extended over a long period of time along a gradually sinking sea-margin.

Subsequent to this deposition the sediments thus formed were elevated above sea-level, and folded into anticlines and synclines. So soon as the land had risen above the surface of the sea, and even possibly before it had reached the surface, its wearing-away had commenced. It is not known to what heights the land rose in those ancient times. It may have been low, hilly, or even mountainous country, though from the absence of glacial *débris* in the formation succeeding the period of elevation it is gathered that, if mountains did exist, they were not elevated to levels of perpetual snow. We do know that after a long period of time, during which erosion was ever active, the land was worn down almost to the level of the sea, producing a peneplain.

The peneplain, as its name implies, was not absolutely a plain, but doubtless owing either to original greater resistance in composition, or possibly of favourable position free from attack by erosive agencies, a few hills remained above the general denuded surface.

Following the peneplanation of the land the land surface was again elevated or relatively elevated with regard to the sea. Possibly as a partial expression of this elevation or since that event came the faulting movements which separated the several blocks of the peneplain to the east of the harbour, tilted the block to the west thereof, and formed the original depression now occupied by Wellington Harbour. The depression in the beginning seems to have been a graben somewhat complex in nature, which extended from the sea up the Hutt Valley. It is probable that at first the down-faulted trough was not entirely beneath the sea, but was occupied by a large stream, the antecedent of the present Hutt River. The erosive influence of this ancient stream profoundly influenced the contours of the original depression before renewed subsidence lowered at least the outer part of the graben beneath the sea.

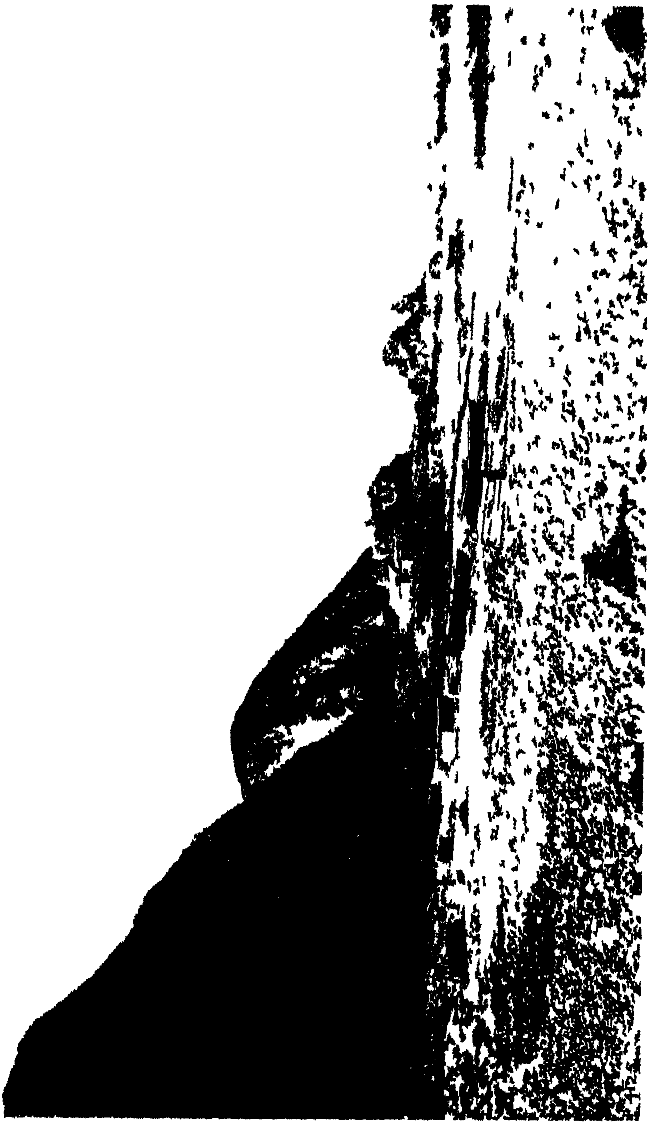


OUTLINE OF HILLS BEHIND WELLINGTON.

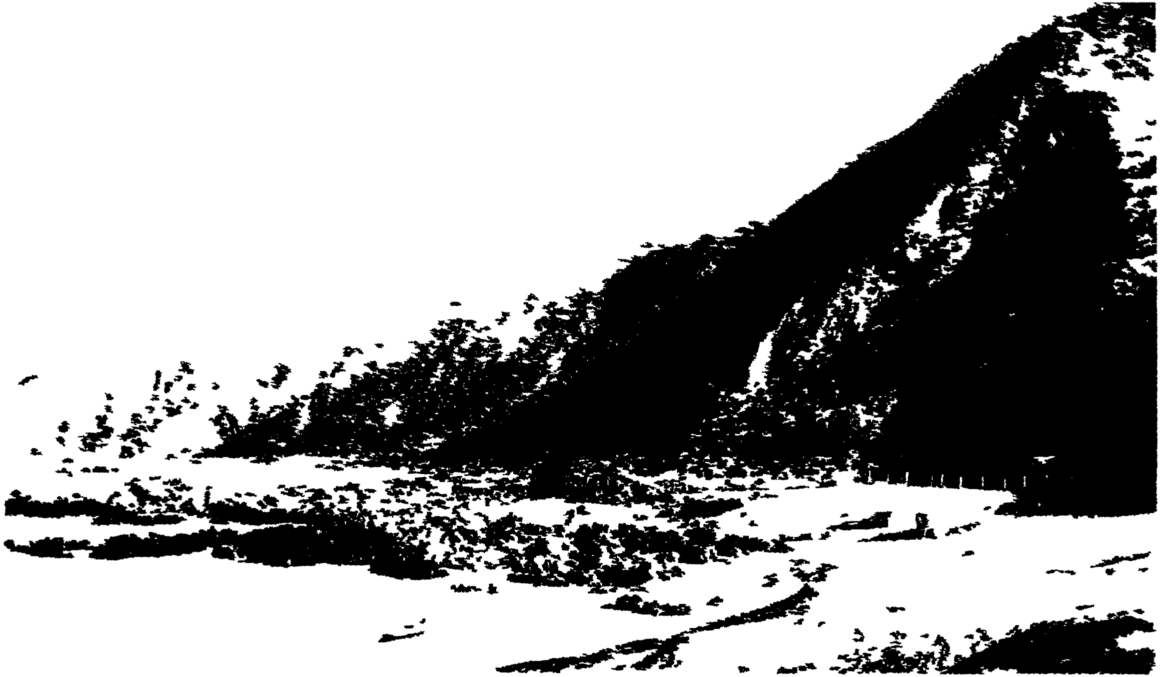
The complicated graben of which the harbour and the lower Hutt Valley are the expressions by no means represents a single depressed block, but consists of several parallel and transverse blocks, not all of which have settled down equally either transversely or longitudinally. Thus the low-lying areas of country between Lyall Bay and Evans Bay and between Island Bay and Lambton Harbour have apparently not subsided to the same depth as the floor of the main body of the harbour, though it is not improbable that both these areas were either originally below sea-level or at least occupied a lower altitude than at present, their height above sea-level and general surface area being increased by wind-blown sands. In the same way it seems evident that the Seatoun Hills, the Kilbirnie Hills, Somes Island, and Ward Island represent either whole blocks or portions of blocks of the peneplain which were after the time of major faulting much higher, and now owe their reduced position and more mature sculpturing, as compared with the surface of the peneplain to the west and of the various blocks of that surface to the east, to the more rapid denudation consequent on their isolated and exposed positions.

Since the final depression of the graben beneath the sea the surface of the land has been much influenced by erosive action—marine, fluviatile, and subaerial. Thus the generally flat surface of the blocks of the peneplain has been dissected by numerous streams into ridge and valley, so that the plain appearance remains only in a few places, such as near Karori and near Johnsonville; and the isolated horsts, such as the Kilbirnie Hills, have been worn into well-rounded ridges with slopes completely cloaked with the deposits of rock-decay.

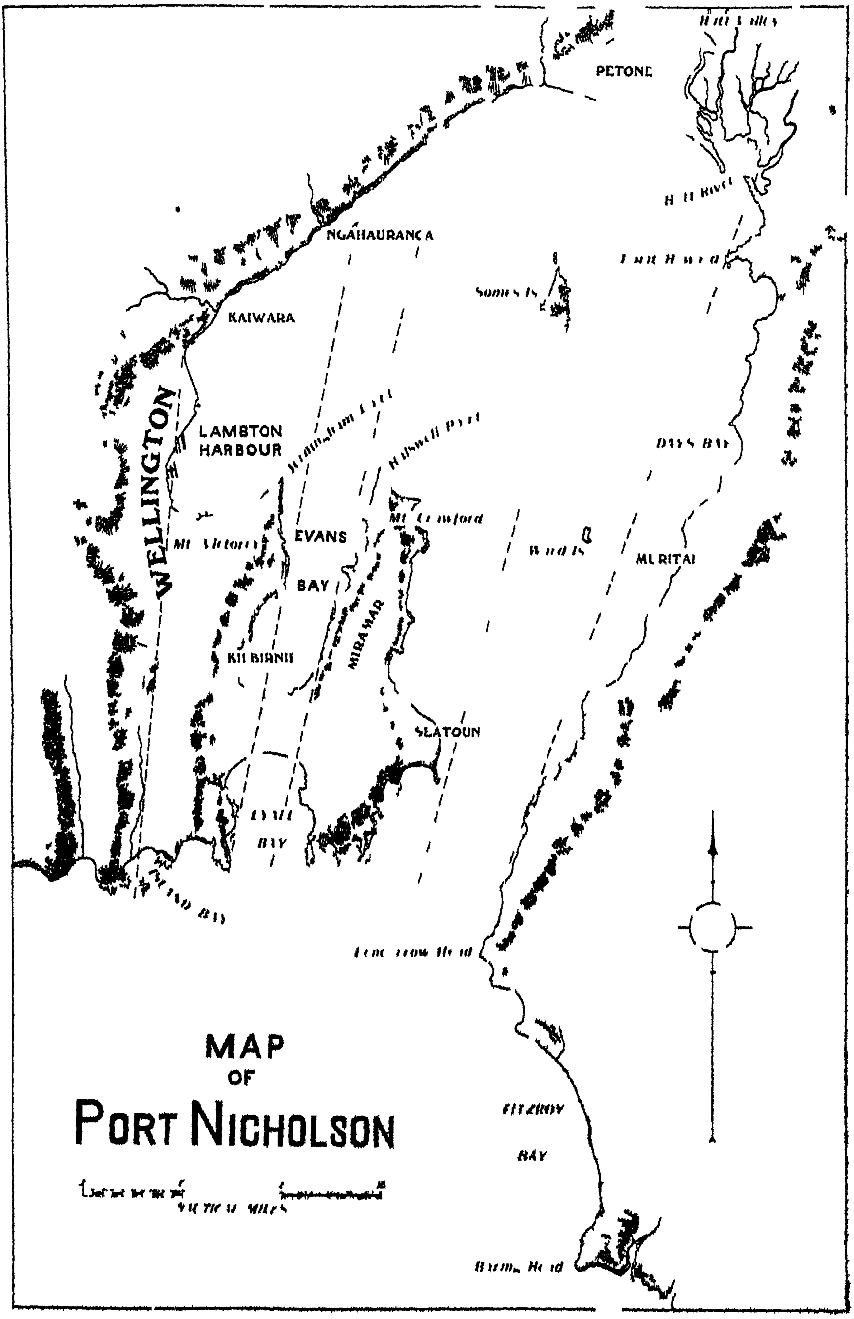
Exactly how far the original depression due to faulting extended up the Hutt Valley is not known, but it is very probable that its apparent area has been much increased by the erosive influence of the Hutt River



RAISED BEACHES NEAR WELLINGTON HEADS.—BELL.



RAISED BEACHES NEAR WELLINGTON HEADS.—BELL.


Hutt Valley
PETONE
Hutt River
Point Howard
NGAHAURANGA
Somes Is
KAIWARA
LAMBTON HARBOUR
WELLINGTON
Point Jerningham
Halswell Point
Mt Crawford
Mt Victoria
EVANS BAY
Ward Is
DAYS BAY
ML RITAI
KILBIRNIE
MIRAMAR
SEATOUN
LYALL BAY
ISLAND BAY
Pencarrow Head
MAP OF PORT NICHOLSON
FITZROY BAY
NAUTICAL MILES
Baring Head

Similarly, too, the wearing-action of the waves has probably increased to some extent the area of the harbour, and undoubtedly modified its boundaries.

The plain along the lower Hutt Valley is but little elevated above sea-level, and has been formed by the laying-down in the original faulted or river-modified depression of material brought down by the rapid-flowing Hutt River. This plain is rapidly advancing into the harbour, thus decreasing the area of that feature.

The time during which the major faulting movements, which have so profoundly influenced the basin of Wellington Harbour and its surroundings, took place is not certain, but it probably continued from late Tertiary times up to the present. A late Tertiary date for the probable beginning of these diastrophic movements is given because we know that faulted Miocene rocks overlie the southern continuation of the peneplain near Nelson and elsewhere at the northern part of the South Island.

That seismic movements have taken place recently in and around Wellington is well known to every student of New Zealand geology and to every Wellingtonian. We owe part of the very limited area of flat land on which a portion of the city is built to one of these tectonic changes—namely, that of the earthquake of 1855. The elevated beaches between Lyall Bay and Seatoun are a magnificent monument of the same event. They stretch for miles along that wild shore, elevated about 5 ft. above the present high-tide level. In places the surface of the beach bordering the steep marine-denuded cliffs is so flat, and is composed of such fine gravel, that it resembles an artificial embankment. Elsewhere occur flats, 5 or 6 chains wide or even more, surmounted by skerries, which until very recently were washed by the waves. Here and there along the seashore fishermen have taken advantage of the recently raised beaches to erect their huts thereon.

More remote from Wellington, recently elevated beaches are said to exist at Palliser Bay and elsewhere; while in Porirua Inlet there is an interesting historical proof of the same upward movement. It is said that the man-of-war's boat which captured Te Rauparaha ascended the Pahautanui to his pa, situated at a point near the present bridge on the main road. Now the stream, even in times of flood, is much too shallow to allow an ascent so far in a similar craft.

The predominant line of faulting in the vicinity of Wellington seems approximately to follow the western shore-line of the harbour, and to this plane of weakness, both past and present, all the other faults by which the graben depression and the blocks of the peneplain have been produced are subsidiary.

The various faulting movements, both recent and more remote, around the site of Wellington are probably connected more or less directly with the extensive movements which have influenced the topography at the north-eastern corner of the South Island, where marked seismic activity has been recently exhibited, particularly in the years 1855, 1888, and 1901.

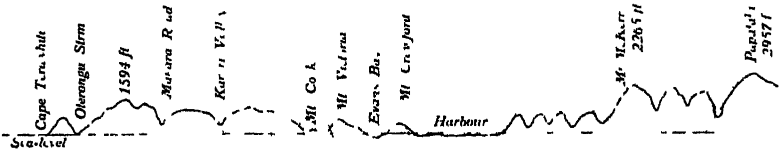
PROOF OF THE GREAT FAULT ALONG THE WESTERN SIDE OF WELLINGTON HARBOUR.

It will be interesting now to give reasons why we know that there has been in the past extensive movements along the western side of the harbour or along the line of major faulting. Even the most casual observer will note that the slope of the hill is remarkably steep—much steeper than the natural angle of rest for the products of decay of such shattered rocks as the argillites and grauwackes of Wellington. This steepness in itself, in the absence of any other explanation, such as glacial erosion, marine denudation, &c., is a physiographic proof of faulting.

A second proof is found in the presence of clay terraces, elevated about 300 ft. above the present level of the sea, on the steep slopes of the Karori Hills at the back of Tinakori Road. These terraces mark the silt-accumulations at the place where the subsidence of the harbourward block forming part of the original complex graben was temporarily arrested.

A still further evidence of the faulting is found in the fact that the small watercourses, such as several of the small streams between Ngahauranga Creek and Petone, do not enter the harbour at grade, as would be the case with normal drainage, but instead flow over the lower part of the fault-scarp in abrupt waterfalls.

Perhaps the most graphic evidence of faulting, however, is found in the gorged nature of all the streams along the western side of the harbour, and in the practical absence of even narrow flood-plains on the largest streams, such as the Ngahauranga. The Ngahauranga flows into the sea over a small gravel fan which it has built out into the harbour. Above this flat the stream flows in a narrow V-shaped gorge-like valley with numerous waterfalls. At its headwaters, where it reaches the level of the peneplain or crest of the block dipping towards Porirua, it flows somewhat more gently.



Section from Cape Terawhiti to Mount Papatahi, indicating Probable Positions of Fault-lines.

The general character of the Ngahauranga is in marked contradistinction to drainage in a hilly or mountainous country unaffected by faulting. There one would expect, with mature topography, a broader valley, the presence of flood-plains, especially towards the mouth, and the absence of waterfalls, save at the headwaters. Of this nature, in fact, is the Porirua Stream, which descends towards the inlet of the same name down the inclination of the tilted block of the old peneplain to the west of the harbour. The stream flows throughout most of its course at grade, flood-plains are common, and waterfalls are infrequent, save at its headwaters. The reason of the difference in character of the two streams will be understood when it is remembered that the Porirua Stream flows down the natural inclination of the block; whereas the other flows contrary to this inclination, across and down the steep fault-scarp.

The actual extent of the throw of the fault at the west side of the harbour is probably not less than 500 ft.

The contrast between Porirua Inlet and Wellington Harbour is as great as that of the two streams which enter them. The inlet is mainly the result of the depression of the lower part of a well-sculptured river valley, while the harbour is primarily an area of complex tectonic subsidence, influenced to some extent by possible fluviatile erosion in the past, and by marine denudation and fluviatile sedimentation.

APPENDIX.

The Falcon Shoals, which occur at the point where the silt and other fine *débris* carried down by the Hutt River are caused to sink by coming in contact with the opposing current of the tide, are nearly three-quarters of a mile across. The shoals consist of sand and clay, with much decomposing vegetable material emitting H_2S, and a few argillite pebbles. The following living species of shell-fish and other marine organisms were identified by Mr. A. Hamilton in the material brought up by the Wellington Harbour Board's dredge a short time ago.

Stichaster insignis.
Amphidotus zealandicus.
Eurynolambrus australis.
Sipunculus maoricus (?).
Echiurus novæ-zealandicus.
Aphrodite aculeata.
Pinna zelandica.
Pecten jacobeus (= P. medius).
Pecten asperrimus.
Pecten zelandicus.
Siphonalia mandarina.
Scaphella (Voluta) pacifica.
Scaphella (Voluta) *var.* gracilis.
Ancilla (Ancillaria) australis.
Turritella rosea.
Subemarginula intermedia.
Panopea zealandica.
Cardium pulchellum.
Chione oblonga.
Tapes intermedia.
Zenatia acinaces.
Diplodonta globularis.
Ostrea purpurea.
Terebratella sanguinea.
Terebratella rubicunda.
Glycimeris laticostatus.
Modiola australis.
Astralium imperator.
Barbatia decussata.
Trichotropis inornata.
Pleurotoma buchanani.

ART. LV.—*Notes on a Collection of Sea-anemones.*

By F. G. A. STUCKEY, M.A., and C. L. WALTON.

[*Read before the Wellington Philosophical Society, 1st September, 1909.*]

THE specimens were collected by Mr. Walton, chiefly on the shores of Manukau Harbour. We find that ten species are represented, of which seven have been previously described. These seven are,—

1. *Actinia tenebrosa* (Farquhar).
2. *Anemonia olivacea* (Hutton).
3. *Sagartia albocincta* (Hutton).
4. *Sagartia vagrans* (Stuckey).
5. *Paractis ferax* (Stuckey).
6. *Bunodes inconspicua* (Hutton).
7. *Cradactis magna* (Stuckey).

The three new species are,—

8. *Paractis fleurei.*
9. *Bunodes rosea.*
10. *Bunodes minima.*

A peculiar phenomenon of companionship was observed between *Cradactis magna* and a small crab (*Halicarcinus planatus*). The crab rested, apparently quite at ease, among the expanded tentacles of the anemone, or clung to the warts on the column. If removed, the crabs immediately scuttled back to the anemone, climbed the column, and settled down again among the tentacles or even on the disc. The anemone made no attempt to close its tentacles over this crab, but if crabs of other species were placed among the tentacles they showed great fear, and attempted to escape. The tentacles closed over the crab, and if any appendages were lost by the latter they were immediately devoured. Three specimens of the *Halicarcinus* sent to Dr. Chilton for identification all proved to be females.

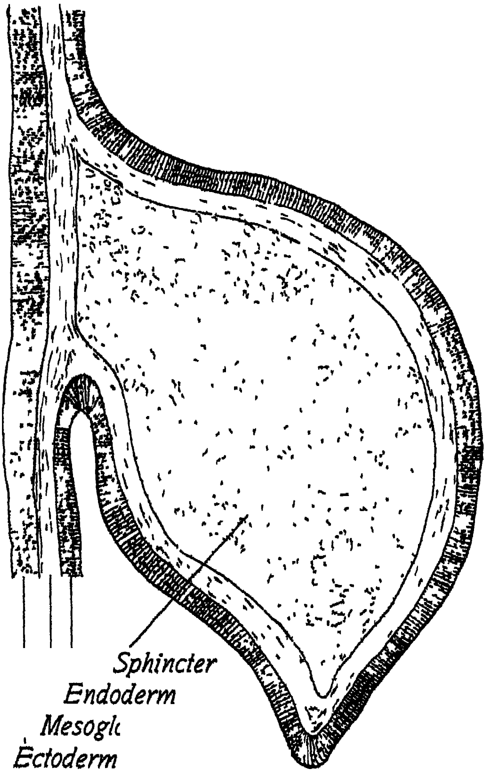


FIG. 1.—PARACTIS FLEUREI.

Paractis fleurei, sp. nov.

Pedal Disc.—Adherent; margin irregular and crenated. Usually imbedded in crevices in the rock.

Column.—Lower part hyaline. Pale at the base, olivaceous above. The upper can be inverted within the lower. It is whitish, with faint-yellow lines.

Oral Disc.—Transparent, with markings that vary in different individuals. These markings may be white lines or a pattern of scarlet, yellow, and white. There are scarlet spots at the bases of the primary tentacles.

Tentacles.—These are slender, of a semi-transparent white, opaque at the bases. They are from 70 to 80 in number.

Sphincter Muscle.—This is imbedded in the mesogloea, and is somewhat pendulous. In transverse section it resembles the profile of a chick's head (fig. 1).

Stomodæum.—White, slightly ribbed.

Mesenteries.—There are 24 pairs, evenly arranged; 12 pairs are perfect, 2 of these pairs being directives (Plate XLIII, fig. 1).

Gonads.—None were present in the specimens from which our preparations were made.

Locality, &c.—Pukeroa. Occurs well up between the tide-marks, and expands in full sunlight.

Bunodes rosea, sp. nov.

Pedal Disc.—Adherent to rocks.

Column.—Olive-green, orange-brown, or umber. Covered with warts; most numerous about middle of column. The warts have suckers, to which particles adhere. There is a row of white spherules on the margin.

Oral Disc.—Yellowish-white, with 12 dark-umber rays, united in the middle of the disc by a circle of the same colour, thus producing a wheel-like pattern. The rays bifurcate.

Stomodæum.—The mouth is raised on a cone, and there are 2 siphonoglyphs, edged with white.

Tentacles.—In three cycles, 40 to 50 in number, probably 12 + 12 + 24 in normal specimens. They are thick at the base, and taper to a point. The colour is rosy red, brightest at the tip and dull umber at the base. They are irregularly marked on the inner surface with bars and spots.

Sphincter Muscle.—Endodermal, circumscribed and somewhat flattened (fig. 2).

Mesenteries.—In our preparations there were 18 pairs. Of these, 9 pairs were perfect, 2 pairs being directives.

Gonads.—The specimen sectioned was a male, containing 4 fertile pairs of mesenteries, each with many spermaries (Plate XLIII, fig. 2, and Plate XLIV).

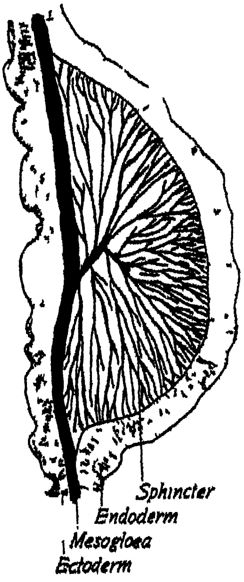
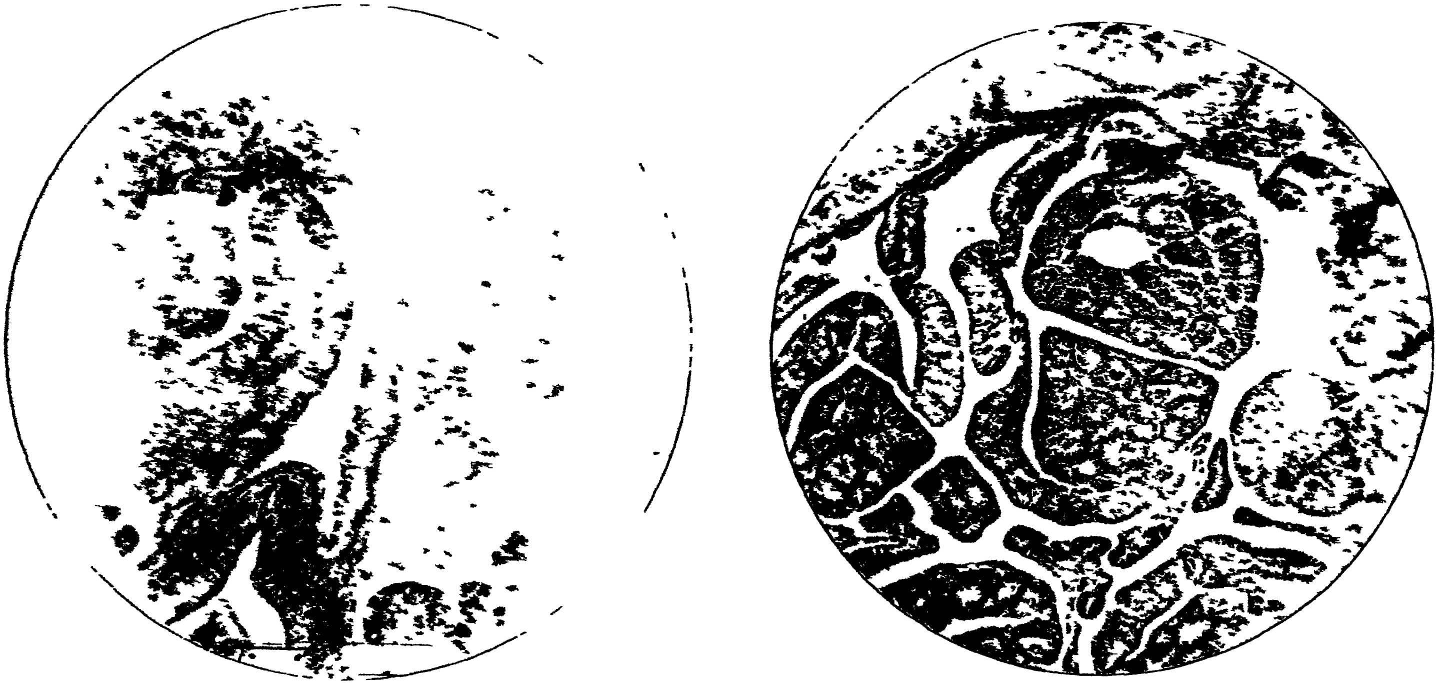


FIG. 2.—BUNODES ROSEA



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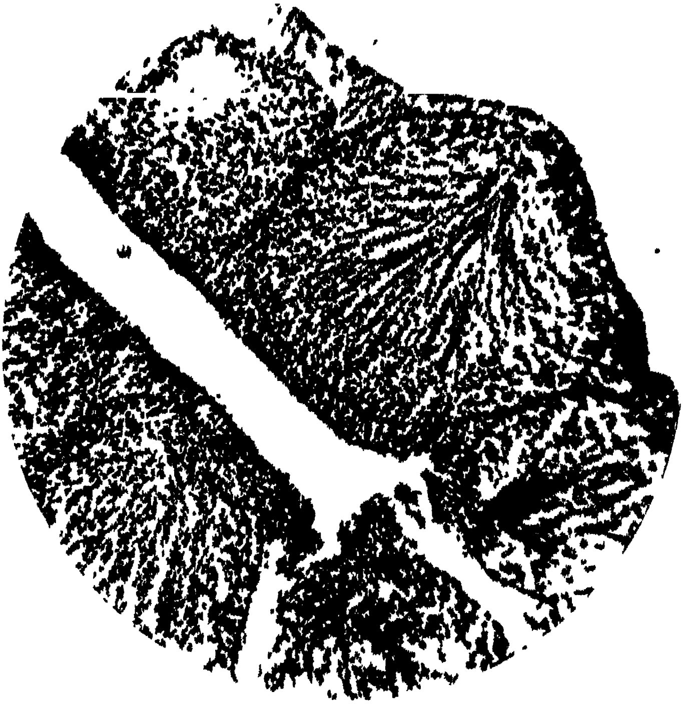
SEA-ANEMONES.—Stuckey and Walton.



SEA-ANEMONES.—STUCKEY AND WALTON.

This species has been observed by us to increase by fission.

Dimensions.—Height of column, 5 mm.; diameter when fully expanded, 18 mm.; diameter of oral disc, 7 mm.; longest tentacle, 6 mm.

Locality.—Pukeroa and neighbourhood.

Bunodes minima, sp. nov.

Pedal Disc.– Adherent to rocks; irregular in outline.

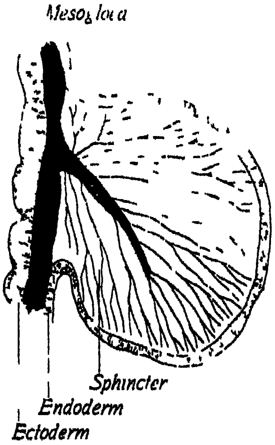


FIG. 3. - BUNODES MINIMA.

Column.—Rosy pink, or light orange. Slightly higher than broad. Wrinkled. Warts few. Marginal beads white or pink.

Oral Disc.—Centre rose-colour. Between this and bases of tentacles is a complicated pattern of light and dark olive-green and grey.

Tentacles.—36 in number. As long as diameter of disc, or slightly more. Fairly stout, tapering gently. Semi-transparent, with white bars and dots. There is a white area round the base, then a few dark lines.

Sphincter Muscle.– Of the typical endodermal type, somewhat rounded (fig. 3).

Mesenteries.—Our preparations showed 14 pairs, unevenly distributed—9 on one side and 5 on the other. Two pairs are directives.

Dimensions.—We did not record the exact dimensions, but the species is smaller than *B. inconspicua.*

EXPLANATION OF PLATES XLIII and XLIV.

PLATE XLIII.

FIG. 1. *Paractis fleuri*: directive mesenteries.
Fig. 2. *Bunodes rosea*: spermaries.

PLATE XLIV.

Bunodes rosea: part of a spermary, very highly magnified.

Art. LVI.—*Description of a New Species of Moth.*

By Alfred Philpott.

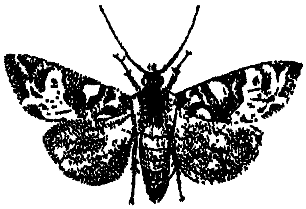
Communicated by Dr. Benham.

[*Read before the Otago Institute, 14th September, 1909.*]

Caradrinidæ.

Melanchra pauca, n. sp.

♀. 38 mm. Head brownish-black, with scattered whitish scales; tuft of greenish-yellow scales at base of antennæ. Labial palpi brown, second joint beneath and apex of terminal, white. Antennæ brown, annulated with whitish near base. Legs black, tibial apices and tarsal joints annulated with white; posterior tarsi reddish beneath. Thorax black, with frontal collar of pale green and whitish green lateral stripe. Abdomen fuscous, anterior segments shading into grey. Forewings, costa almost straight, apex subacute, termen oblique, pale yellow-green; base narrowly black, with projection at middle; *a broad irregular black fascia from dorsum near base, touching basal patch*, its apex connecting with similar fascia from costa at ¼ outwardly oblique to dorsum at ½; this fascia encloses narrow line of ground-colour from costa to vein 1; *a broad irregular black fascia at ½, dilated on costa and joining first costal fascia above dorsum*; stigmata obscure, reniform, pale greenish anteriorly outlined in black and followed by a reddish patch; a few dark scales in upper portion; a triangular spot on costa near apex, its base dilated and containing several spots of ground-colour; subterminal line irregular, interrupted, green; terminal band black, interrupted from ½ to ¾; veins faintly marked with black scales. Hindwings fuscous.



Type in collection Otago Museum.

Not to be confused with any other species: *exquisita* is green and black, but the arrangement of the fasciæ is quite different. Only three specimens are known to me—two in the collection of the Otago Museum (labelled "Wairarapa"), and one worn example in my own possession, taken in March, at Wallacetown. I am indebted to Professor Benham for the loan of one of the Otago Museum examples for the purpose of figuring. None of the specimens available are in good condition, and the description of thoracic crests and wing cilia had perforce to be omitted.

ART. LVII.—*Observations on some New Zealand Halophytes.*

By MISS B. D. CROSS, M.A.

[*Read before the Philosophical Institute of Canterbury, 1st September, 1909.*]

INTRODUCTORY.

DURING the last hundred years there has been published an ever-increasing volume of literature on the so-called halophytes—that is, plants occupying situations where there is a superabundance of salt in the soil. This special group of plants has been studied from all points of view—morphologically, anatomically, physiologically, and ecologically.

To some extent this order is chronological, for the first observers gave their attention to external characters only, anatomical characters being considered at a later date, while the ecological aspect has been the subject of more modern papers. The physiological section of the subject still opens up much field for research. At the very outset it is yet a debatable point whether halophytes are to be considered salt-loving or salt-enduring plants.

HISTORICAL.

According to Lesage (II, p. 6),[*] as early as 1801 an article on maritime plants appeared in "L'Encyclopedie," where it is noted that such plants are usually succulent, and have closely packed tissues (*tissu serré*). After this date, and until the publication of his own book, Lesage considers that the works of the following authors are the most noteworthy: Moquin-Tandon (1841), Willkomm (1852), Lecoq (1854), Duval-Jouve (1875), Vesque, and Prillieux; and among these he gives the first place to that of Duval-Jouve.

Before the appearance of Lesage's thesis, however, came the work of Constantin "La Flore du littoral."[†] M. Constantin notes more especially the external variations of maritime varieties, though he says that "It is very probable that anatomical study will reveal modifications even where the outward appearance would not lead one to suspect so."

The works which have been most consulted for the compilation of this paper, and more especially for the anatomical part of it, are those of Lesage (II) and Warming (V and VIII), though several shorter papers by American writers were found very useful for comparison (see bibliography, p. 574).

Of New Zealand authors, Cheeseman (XVII) has been found invaluable for identification of species. The New Zealand halophytes, however, have been very much neglected, for, with the exception of a recent paper of Dr. Cockayne's on "The Coastal Vegetation of the South Island of New Zealand" (XIX), there has been no special work on this part of the flora.

SCOPE OF THE PAPER.

In the present paper it is proposed to deal with certain typical halophytic formations in the neighbourhood of Christchurch, and to compare these with similar formations at Timaru.

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[*] The numbers refer to the bibliography, page 574.

[†] Jour. de Bot., 1re année, No. 3, p. 44, 1887.

The body of the paper consists of two parts: (1.) A general description of life-forms, and of variations of each species according to station. (2.) A short anatomical account of certain of the more characteristic plants of each formation. Attention also will be given to such general conclusions as may be drawn from observations of the plants and their habitats, and some comparison made between these and the results given by authorities on the subject.

METHODS OF OBSERVATION.

The methods employed may be divided, roughly, into two classes—(1) Field-work; (2) laboratory-work. Unfortunately, almost the whole of the field-work had to be done during the winter months - a serious drawback, more especially in the case of annuals. It is for this reason, most of all, that no mention has been made of the flowers of the different species, except in a few cases of flowering out of their usual season.

To supplement the field-work, plants of several of the species observed were planted, some in the open flower-beds, others in the greenhouse at Canterbury College, and these have been examined from time to time, and compared with specimens from their natural habitats.

DISTRICTS OBSERVED, AND PLANT FORMATIONS.

The Heathcote, on the banks of which most of the field-work has been done, is a small, sluggish stream that forms with the River Avon an estuary, invaded by every high tide, and left a barren expanse of mud at its ebb. Both streams are for a considerable distance affected by the tides, and so their banks and the immediate surroundings of the estuary are favourable situations for halophytic plants. Nowhere do they flourish better than in the little patch of ground in the last bend of the Heathcote, and in this comparatively small area there exist at least three different plant formations: (1) Salt-marsh formation; (2) salt-meadow formation; (3) brackish-water formation.

Of the first of these, the salt marsh, it is difficult to say which is the dominant species. Probably it would be better to say that there are really two dominant species, *Leptocarpus simplex* and *Juncus maritimus*. Looking over the expanse of rushes in the winter, one sees alternately dark and lighter patches, the former being composed of *L. simplex*, the latter of *J. maritimus*. The monotony of these acres of rushes is broken only by purplish-grey clumps and lines of *Plagianthus divaricatus*. These three species, then, are the sole occupants of the greater part of the salt marsh; but at its extreme edge there are a few of the typical species of the salt meadow. These plants must have been excluded from the salt marsh through their inability to cope with the rushes, and not through any unsuitability of edaphic conditions, for the few found there are particularly luxuriant.

In the salt meadow the vegetation is more varied, and is composed of a turf of close-growing plants with creeping stems. The mats of *Salicornia australis* and *Selliera radicans* form the most noteworthy feature of this formation.

Again, the salt meadows are traversed by channels, evidently dug for drainage purposes, and these, at high tide, are filled with water. Here *Plagianthus divaricatus* is the dominant species, though all the plants of the salt meadow, with the exception of *Atriplex patula*, and the addition of *Samolus repens*, root in the sides of the channels, or even in the very bottom.

It is perhaps worthy of note that in the channels, and also in the mud-flats, are innumerable holes of small land-crabs (*Heterograpsus crenulatus*, M. Edw.). Dr. Cockayne (XIX, p. 316) is of opinion that these "must assist materially in aerating the soil, and, to some measure, also in draining the ground."

For purposes of comparison, observations were made also along the banks of the Avon, near New Brighton. Here there are practically the same formations, though they are not in all cases made up of the same members as those at Heathcote. In the salt marshes, for some reason, *Leptocarpus simplex* is much more in evidence than *Juncus maritimus*. The salt meadows, however, are dotted with clumps of the latter rush. Again, out in the meadows are wide pools of brackish water, much less salt than that of the channels of Heathcote. Here there occur, in great numbers, plants (wholly submerged in winter) of *Mimulus repens* and *Cotula coronopifolia*; the latter also a vigorous denizen of the salt meadows.

Both New Brighton and Heathcote were visited from time to time—Heathcote from April to October, New Brighton from July to October; but during the month of June some small amount of work was able to be done at Timaru. Here there are a series of lagoons, separated from the sea only by a very narrow shingle-bank. The first point noticed was that here rushes and rush-like plants do not form a characteristic feature of the landscape. In the neighbourhood of the one lagoon which was comparatively easily approached, only one small tuft of *J. maritimus* was collected. This, perhaps, may be accounted for by the fact that there are no mud-flats, the soil being of a rather sandy nature. An even more striking fact is that, whereas at Heathcote all the halophytes grow side by side in the salt meadow, at Timaru comparatively large tracts round the edges of the lagoon are occupied solely by *Salicornia australis*. One small hollow stretching between two shingle-banks presented, in June, a very peculiar appearance, for it was divided longitudinally into two almost equal halves—one half thickly covered with withered mats of *S. australis*, the other with a bright-green turf of *Cotula coronopifolia*. On closer inspection, it was seen that in this matted growth of *Salicornia* there were innumerable seedlings of *Cotula*, which evidently could not find a foothold there while the *Salicornia* was in a flourishing condition. All the typical plants of the salt-meadow formation, except *Samolus repens* and *Spergularia media*, were found out in the grass at the edges of the neighbouring fields. Some, again, especially *Selliera radicans* and *Apium prostratum*, have established themselves among the rocks of a railway embankment, and here also, though nowhere else in the locality, are a few low grey bushes of *Plagianthus divaricatus*.

LIST OF SPECIES IN NATURAL ORDERS.

A. CYPERACEÆ.

1. *Scirpus americanus*, Pers.
2. *Scirpus lacustris*, Linn.
3. *Scirpus maritimus*, Linn.
4. *Carex litorosa*, Bail.

B. RESTIONACEÆ.

5. *Leptocarpus simplex*, A. Rich.

C. JUNCACEÆ.

6. *Juncus maritimus*, Lam.; var. *australiensis*, Buchen.

D. CHENOPODIACEÆ.

7. *Atriplex patula*, Linn.
8. *Salicornia australis*, Soland.

E. CARYOPHYLLACEÆ.

9. *Spergularia media*, Presl.

F. MALVACEÆ.

10. *Plagianthus divaricatus*, Forst.

G. UMBELLIFERÆ.

11. *Apium prostratum*, Lab.; var. *filiforme*.

H. PRIMULACEÆ.

12. *Samolus repens*, Pers.; var. *procumbens*, R. Knuth.

I. SCROPHULARIACEÆ.

13. *Mimulus repens*, R. Br.

J. GOODENIACEÆ.

14. *Selliera radicans*, Cav.

K. COMPOSITÆ.

15. *Cotula dioica*, Hook.
16. *Cotula coronopifolia*, Linn.

DESCRIPTION OF LIFE FORMS.

(*Abreviations*—H.C. = Heathcote; N.Br. = New Brighton; Tu. = Timaru.)

As the first four species in the above list occur plentifully only at New Brighton, and as this was not visited till July, only their withered leaves were collected; and, so, few particulars of the life forms could be given. It was thought better, however, to mention, at any rate, their station rather than leave them out altogether.

1. Scirpus americanus.

Station.—(1.) H.C.: Absent from all formations. (2.) N.Br.: In channels of brackish water in the salt marshes. (3.) Tu.: Unrepresented.

Life Form.—From the great profusion of dry, withered leaves, one would imagine that in the previous summer the channels must have been fairly choked with a dense growth of this plant. It grows from a perennial, long, black rhizome. The leaves are linear, concave and grooved, sheathing, and covered with short stiff hairs.

2. Scirpus lacustris.

Station.—(1.) H.C.: In the water at the edge of the river, commencing some distance up stream. (2.) N.Br.: As at H.C. (3.) Tu.: Unrepresented.

Life Form.—Of this, the stems only were found growing from a rhizome. According to Cheeseman, leaves are absent.

Stems short and cylindrical.

3. Scirpus maritimus.

Station.—N.Br. (only): In the channels with *S. americanus*, but extending further out into the marsh.

Life Form.—It was not distinguished with any certainty from *S. americanus*. The leaves appeared somewhat broader.

4. Carex litorosa.

Station.—(1.) H.C.: Very sparingly in the salt marshes at the border of the rushes. (2.) N.Br.: In rather greater numbers, but occupying same station as at H.C. (3.) Tu.: Not collected.

Life Form.—Compact tufts, with numerous fibrous roots.

Leaves long, narrow, grooved, the inner surface concave. They are produced into long thread-like points, which in the dead leaves collected were twisted into fantastic spirals.

5. Leptocarpus simplex.

Station.—(1.) H.C.: Associated with *Juncus maritimus* in the salt marshes. (2.) N.Br.: As noted previously, it is here the dominant species of the salt-marsh formation. (3.) Tu.: Absent from the vicinity of the lagoons.

Life Form.—A rush-like plant, growing from a stout creeping rhizome, covered thickly with brown scales.

Stems 30–150 cm. high, about 1 mm. in diameter, numerous, unbranched, cylindrical. They are extremely tough and wiry, with narrow internodes 4–10 cm. long.

Leaves reduced to the sheathing-scales, which clasp the stem closely. Each scale is composed of an outer membranous skin and an inner glassy, brown, thicker coat.

6. Juncus maritimus, var. australiensis.

Station.—(1.) H.C.: Salt marshes. (2.) N.Br.: Salt marshes, and also in scattered clumps over the salt meadows. (3.) Tu.: Though, according to Cheeseman, not found further south than Banks Peninsula, a few plants were collected in the neighbourhood of the lagoons.

Life Form.—A typical rush, growing from a short, stout, brownish rhizome, giving off stems 30–90 cm. high, numerous, rigid, dark-coloured, cylindrical, ending in sharp points. They are of greater diameter (up to 3 mm.) than the stems of *Leptocarpus simplex*, but hardly so wiry. They are marked longitudinally with narrow ridges and grooves. At the base of the stems are brown scales, the inner ones of which are produced into cylindrical pungent leaves of exactly the same appearance and structure as the stems. These leaves clasp the bases of the stems.

This variety, according to Cheeseman (XVII), "differs from the typical state of the species in the darker colour of the plant, in the smaller and more densely aggregated darker flowers, in the shorter capsule, and in the less evident tails to the seeds."

7. Atriplex patula.

Station.—(1.) H.C.: Isolated plants scattered all over the salt meadow, some even down to the edges of the mud-flats. (2.) N.Br.: As at H.C. (3.) Tu.: Out in the grass meadow, and also in prostrate clumps on the shingle-bank.

Life Form.—An annual herb, with main axis (30–60 cm. high) erect; but the branches crowded at its base are quite prostrate, and, as they may reach a length of 25 cm., the plant may occupy a considerable area. This is the case in the damper portions of the meadow; but in the higher stony parts the plant is exceedingly stunted, scarcely ever exceeding 10 cm. In striking contrast to this, specimens from the marshes may reach the height of 90 cm., while the branches are correspondingly longer, and the lower ones are ascending instead of being prostrate.

According to Cheeseman, the plant is green, but all those from the above stations exhibited a reddish appearance, owing to colour in both stem and leaves.

Stem and branches are deeply grooved, and tomentum occurs in the grooves.

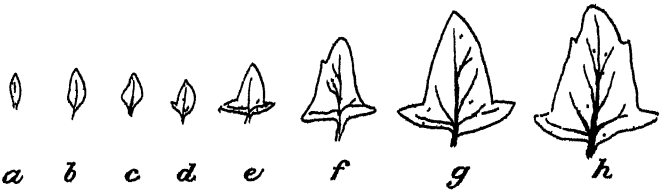

FIG. 1.—VARIATION IN LEAVES OF ATRIPLEX PATULA.

Leaves 1–4 cm. long, in a more or less vertical position, generally opposite; but the upper ones may be alternate, very variable in shape, the upper ones being almost linear or linear-lanceolate, the lower ones hastate, while there appear many transitions between these two types. They are shortly petiolate, exstipulate, and have acute apices and entire or sparingly toothed margins. Both upper and lower surfaces are covered with a mealy tomentum. In the dried parts of the meadow the leaves are smaller and very rarely hastate; sometimes they are almost sessile. In the marshes the leaves reach their greatest size, and have the typical hastate shape.

The main root is fairly stout, and has numerous secondary branches.

8. Salicornia australis.

Station.—(1.) H.C.: (*a.*) In the channels, sometimes almost completely submerged. (*b.*) Very abundant in the salt meadow, even in the driest parts, associated with the other typical plants of the meadow, though perhaps the dominant species. (*c.*) On the edge of the mud-flats, beneath the rushes. (2.) N.Br.: It occupies here much the same positions as at H.C., but occurs also completely submerged in the brackish waters of the pools at some distance from the river itself. (3.) Tu.: Crowding out almost all vegetation, except *Cotula coronopifolia*, for some acres round the lagoon and the stream which enters it.

Life Form.—A perennial semi-fruticose plant with numerous spreading succulent branches which may be quite prostrate, procumbent, ascending, or stiffly erect.

The branches are very succulent, though sometimes woody at the base. In winter most of them die down, leaving the dry, woody lower parts, which send out fresh succulent branches in the spring, or, indeed, in winter should a few mild days intervene. In the more sheltered situations the ordinary succulent branches are persistent throughout the whole year. In form they are jointed with internodes 1–2 cm. long, 2–3 mm. in thickness, and cylindrical, except at the joints, where they are slightly flattened, and produced into two short lobes, with membranous edges. Each pair of lobes is at right angles to the pair immediately above. The whole plant is perfectly glabrous.

Leaves are entirely absent.

Roots are short and very woody, and sometimes spread horizontally for a considerable distance.

Inflorescences were found in autumn and the early part of the winter at the ends of the branches. They are in the form of spikes, slightly thicker than the branches they terminate. The flowers are ambisporangiate, and sunk in the joints, which are here much shorter. Each flower has a fleshy perianth, a single rather conspicuous stamen, two styles, papillose stigmas, and one erect ovule.

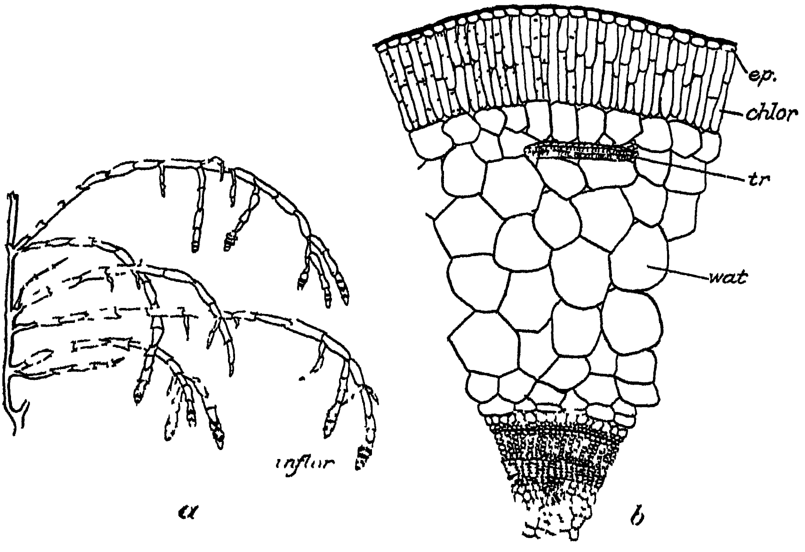

FIG. 2.—SALICORNIA AUSTRALIS.

a. Branches with terminal inflorescences, half natural size. *b.* T.S. of succulent stem, × 38.

This species varies much according to station. When wholly or partially submerged it is paler green, much less rigid, and has larger internodes than the ordinary form of the salt meadow. It assumes very much the same appearance out in the marshes, though the branches are slightly more rigid. In the meadows it forms a dense, matted growth, with short branches stiffly erect. In one part, at Heathcote, where a narrow belt of meadow stretches right out to the river, *Salicornia* is found rooting on the upper edge of the bank, and hanging down almost to the surface of the water. The branches in this place reach a length of 60 cm., and they may cover the banks very thickly, those nearest the bank being very hard and woody, the more superficial ones of the ordinary succulent type.

At Timaru *S. australis* forms a thick carpet almost without a break, and is recognisable at a considerable distance by its conspicuous reddish colour. This red colour is found also to some extent in the stem of *Salicornia* at H.C. and N.Br., but not so markedly as at Tu., for it appears only in a few scattered individuals. Probably this difference is due to a greater amount of salt in the soil in the vicinity of the Timaru lagoons, which, as it was shown above, are separated from the sea only by a very narrow bank of shingle, and are sometimes even invaded by it. With reference to this, Ganong (xi, 355) may be quoted. In his section on the *Salicornetum*, he says, "In general, its members are more stiffly upright, sparser, and redder the salter the place." Comparison of the life forms of *S. australis* according to station would seem to confirm this, except that it occurs not sparsely but very luxuriantly right down to the edges of the lagoon.

9. Spergularia media.

Station.—(1.) H.C.: In the more sheltered parts of the salt meadows; not very plentiful. (2.) N.Br.: As in (1). (3.) Tu.: Not collected.

Life Form.—A succulent perennial herb of a somewhat loose cushion-like habit.

Stems 3–10 cm. long, branched, generally prostrate, with a few short erect branches. In some cases longer, sparingly branched, straggling stems are given off from the cushion.

Leaves 2–4 cm. long, opposite, in pairs. In the axils of the leaves are short branches, with their young leaves, and so they appear as if arranged in whorls. Probably this is Dr. Cockayne's reason for calling them "tufted" (xix, p. 348). They are fleshy, almost cylindrical, but slightly flattened on their upper surfaces, and have sharply acute apices. At each node the bases of the young leaves are covered with two membranous stipules, which are opposite and combined for about two-thirds of their length, their sharply pointed apices being free. Later on, when the leaves lengthen and spread out, the two stipules become torn apart. Stems and leaves are covered, but not thickly, with tiny white hairs.

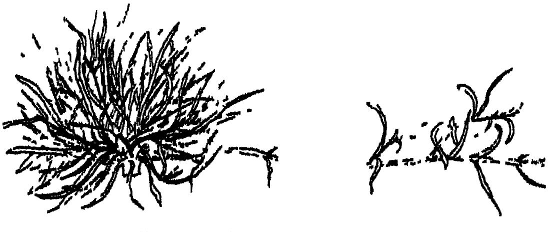

FIG. 3.—SPERGULARIA MEDIA.
Part of cushion with one free branch, half natural size.

The root is a long stout tap-root, with few rootlets.

No flowers of this species were collected, but fruits were found in April. The fruit is a three-valved capsule.

10. Plagianthus divaricatus.

Station.—(1.) H.C. : (*a.*) A more or less close line marks out the course of almost all the channels; it is noticeable that the bushes do not root actually in the water, but about half-way up their moist banks. (*b.*) Solitary bushes are scattered all over the salt meadow. (*c.*) Lines and clumps break the monotony of the acres of rushes in the marshes; these lines of bushes, in some cases almost straight, at first sight might appear to have been planted in this fashion for hedges, but on close inspection it may be seen that they follow the course of streams, or, at least, damper parts in the marshes. (2.) N.Br. : As at H.C. (3.) Tu. : Only a very few bushes were found, and these, in marked contrast to those at H.C. and N.Br., were in the very driest situation—namely, among the rocks of the railway embankment.

Life Form.—A compact, low-growing, much-branched, coprosma-like shrub, 4–8 ft. high according to Cheeseman, but none were observed over 6 ft. in height. The plant as a whole presents a dull grey appearance, sometimes with a slightly purplish tinge. It is one of the few deciduous New Zealand plants. It is practically deciduous, for in the more exposed parts all the leaves fall off in the beginning of the winter, except a few towards the very innermost parts of the bush, where they are protected by the interlacing mass of branches. The few straggling bushes at Timaru are quite deciduous.

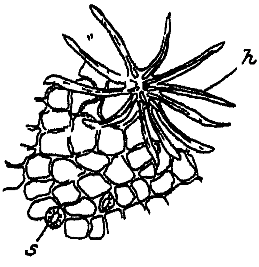

FIG. 4.—PLAGIANTHUS DIVARICATUS.
Epidermis, showing glandular hairs, highly magnified.

The branches are extremely tough, slender, divaricating. Very often they are much interlaced. This is more noticeable in those at H.C. and N.Br. At Tu. they are less branched, and spread out rather more freely.

Leaves are alternate, or, more commonly, fascicled, 2–10 mm. long (though in seedling forms they may be twice this length), linear, obovate, or lanceolate. The margin is entire, and the apex generally obtuse, though sometimes acute. Cheeseman describes the leaf as "one-nerved"; but there is a quite distinct, complex, reticulate venation.

Roots are short and stout, branching horizontally.

A short account of the flower may be given here, as flowers were collected at Heathcote from the 21st June, though Cheeseman gives the period of flowering as September–October. This early flowering is rather surprising so far south, more especially as the winter has been rather severe. Again, of the genus Cheeseman says, "The New Zealand species are practically diœcious, although a few hermaphrodite or female flowers are occasionally mixed with male ones"; but every flower examined was found to be hermaphrodite, though strongly protandrous. It may be possible that the gynœcium in some cases has been overlooked, as it is very small at a stage when the andrœcium is relatively large.

A curious point, too, is that, though typically there are five sepals, almost every calyx had a small extra sepal opposite one of the petals. The andrœcium, again, is worthy of note on account of its large pollen-grains with conspicuous spiny projections. The stigmatic surface is very markedly papillose.

Fruit was collected in April. It is a dry, downy capsule, splitting irregularly.

N.B.—Many of the bushes are clothed quite thickly with a growth of lichens.

11. Apium prostratum, var. filiforme.

Station.—(1.) H.C.: (*a.*) On the channels, rooting in the edges of the banks, and forming more or less straggling clumps. It is rather remarkable that in one of the channels *A. prostratum* is almost the only plant occupying the banks; the channel is a very moist one, and is very much shaded by the built-up road above, and it is some distance from the river. No bushes of *Plagianthus* and very few of the smaller plants of the channels appear here; but nowhere else is *Apium* so flourishing. (*b.*) It occurs more or less sparingly in the meadows. (2.) N.Br.: As at H.C. (3.) Tu.: (*a.*) A few plants of *Apium* were collected near the lagoon, but they belong, in all probability, to the introduced *Apium graveolens*, as the leaves are larger and very different in shape from the variety *filiforme*. There is a possibility, however, that these are one of the other varieties of *A. prostratum*: the same form was collected in the salt meadows at Heathcote. (*b.*) Undoubted examples of *A. prostratum*, var. *filiforme*, form clumps on the railway embankment. It is remarkable here, also, as in the case of *Plagianthus*, that whereas at H.C. the plant is found mostly in the damper situations, at Tu. it is in the very driest.

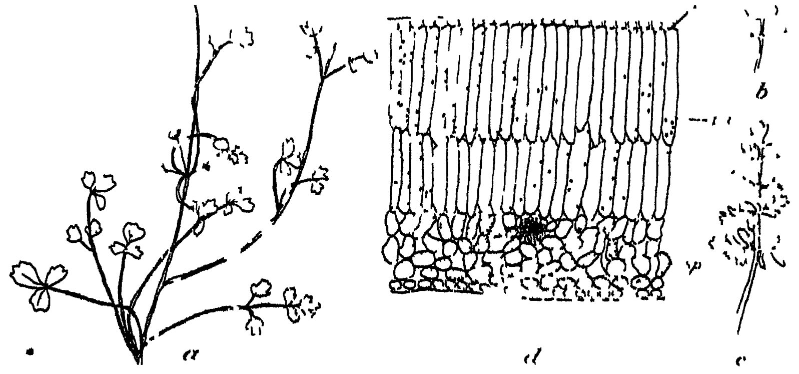

FIG. 5.—APIUM PROSTRATUM, VAR. FILIFORME.

a. Branches, half natural size. *b.* Trifoliate leaf, half natural size. *c.* Leaf, *Apium graveolens* (?), half natural size. *d.* T.S. leaf from plant growing in channel, × 50.

Life Form (fig. 5, *a*).—Perennial, perfectly glabrous herb.

Stems slender, up to 60 cm. in length, prostrate or decumbent in the case of plants in the channels; short (about 5 cm.), erect or suberect in the meadow forms.

Leaves fleshy, trifoliate, each leaflet with a short petiole, rarely sessile (fig. 5, *b*). Leaflets 5–15 cm. long, more or less lobed or serrated, with obtuse apices.

Roots are long and stout.

12. Samolus repens.

Station.—(1.) H.C.: (*a.*) In the channels, either actually in the water, or rooting in the moist edges of the banks, associated with *Selliera radicans*, and forming with it a dense, overhanging growth; it is especially luxuriant in the shade of the bushes of *Plagianthus divaricatus*. (*b.*) On the edge of the salt marshes, where it occurs more abundantly than any of the typical halophytes of the meadows which have strayed there. (2.) N.Br.: As at H.C. (3.) Tu.: Absent from all formations. It is noteworthy that it is altogether absent from Tu. and also from the meadows at H.C. and N.Br.

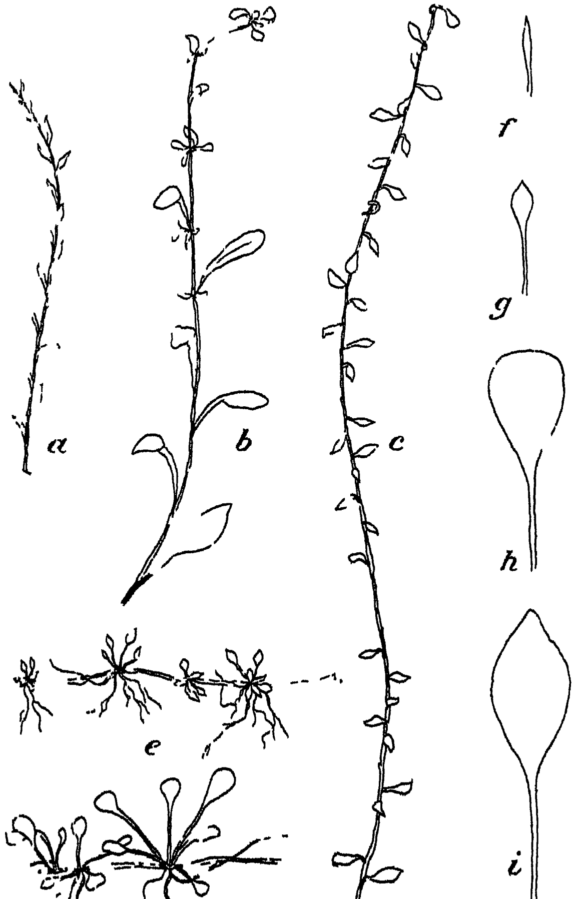

FIG. 6.—SAMOLUS REPENS.

a. Stem of var. *stricta* (?), half natural size. *b.* Ascending branch in the shade of *Plagianthus divaricatus* at H.C., half natural size. *c.* Prostrate branch (N.Br.), half natural size. *d.* Creeping stem from N.Br., half natural size. *e* Creeping stem from H.C., half natural size. *f.* Leaf of *a*, natural size. *g.* Leaf of *e*, natural size. *h.* Leaf of *d*, natural size. *i.* Leaf of *b*, natural size.

Its absence from the salt meadows at Timaru may be accounted for by the fact that the soil there is of a sandy nature; but its presence only in the damp situations at H.C. and N.Br. would seem to point to the conclusion that, when driven from the edges of the lagoons by the more vigorous *Salicornia australis* and *Cotula coronopifolia*, it was unable to thrive in the somewhat dry, exposed salt meadow.

Life Form.—Small perennial herb, with slender stems 10–30 cm. long. According to Cheeseman the stems are glabrous; but, although no actual hairs are visible to the naked eye, the stems have a roughened appearance, and, by running the finger down one of them, one comes in contact with very small, bristle-like projections. The plant grows from a tough creeping rhizome, giving off at the nodes rosettes of leaves and sparingly branched adventitious roots (fig. 6, *a–c*). In the shade of the *Plagianthus* bushes, or of the rushes, however, the stems are erect or ascending, 10–30 cm. long, sometimes giving off stolons from their bases.

Leaves 4–32 mm. long, slightly fleshy, very variable in size, colour, and shape. The margins are invariably entire.

It is remarkable that the prostrate form at N.Br. differs very much in general appearance from the same form at H.C., though the two places are so short a distance apart—three miles. At H.C. the leaves form dense mats of bright-green colour. They are lanceolate in shape, with acute apices, and the petiole is marked off rather sharply from the lamina (fig. 6, *e*). At N.Br. the rosettes are not united into such dense masses, the leaves are of a dull, greyish green, and are obovate with very obtuse apices, while petiole and lamina are not sharply marked off from each other (fig. 6, *d*, *h*). On the erect branches (fig. 6, *b*), in the shade of the *Plagianthus* bushes, the leaves reach their greatest size. Towards the upper part of the branch they are small, with short petioles, or sometimes almost sessile; and they are arranged in alternating whorls. Lower down are larger, single leaves, with petiole and blade of about equal length. These are broadly lanceolate. Stipules are absent in all cases. Fig. 6, *c*, shows a long trailing branch found overhanging a bank at N.Br. The leaves are small, shortly petiolate, and appear singly, not in whorls. This branch was at first mistaken for one of *Selliera radicans*; and the mistake was not detected until a microscopic examination of the leaves was made, as it was remarkably like branches of *Selliera radicans* found in the same situation (fig. 7, *e*).

About two years ago, a plant of *Samolus repens* was brought from the Poor Knights Islands by Dr. Cockayne, and planted in the College rockery. This plant differs so much in general appearance that Dr. Cockayne considers it a separate variety, giving it the MS. name of *stricta*.*

The branches are all quite erect, and are very slender. The leaves are small, 6–10 mm. long, quite sessile, bright green, and linear (fig. 6, *a*, *f*).

13. Mimulus repens.

Station.—Collected only at N.Br., and here only in the pools of brackish water in the meadows. All the plants found were completely submerged. It is undoubtedly the dominant species of these pools, though *Cotula coronopifolia* also occurs rather plentifully in patches.

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* Trans. N.Z. Inst., vol. xxxix, p. 356.

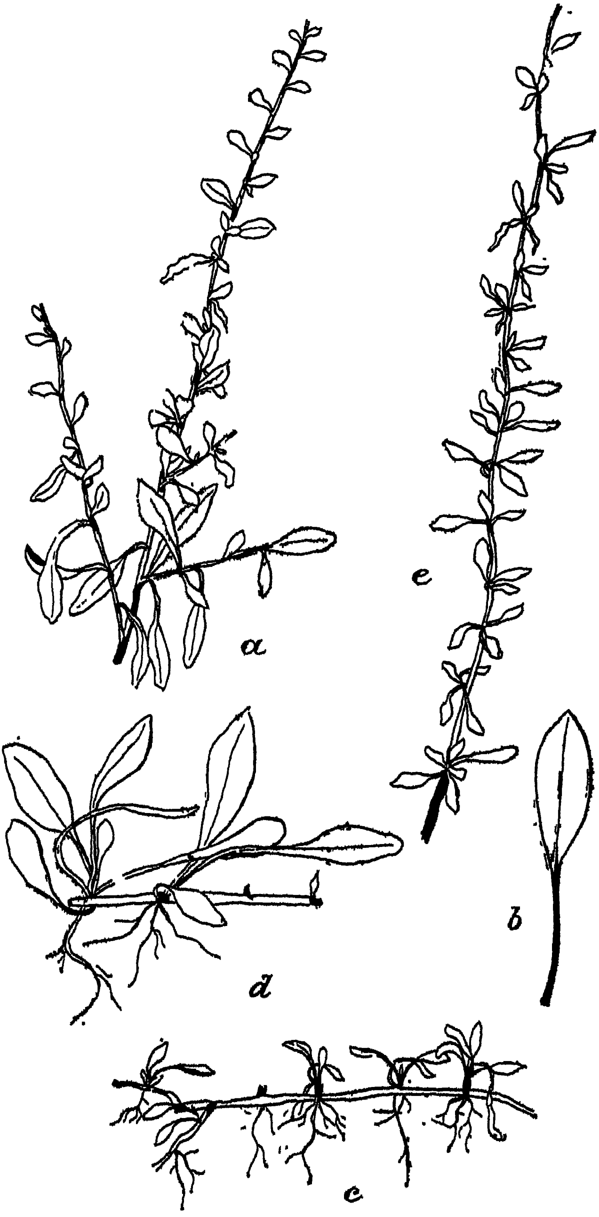

FIG. 7.—SELLIERA RADICANS.

a. Ascending branch, half natural size. *b.* Leaf of *a*, half natural size. *c.* Creeping stem from salt meadow, half natural size. *d.* Creeping stem from marsh, half natural size. *e.* Stem overhanging bank of channel, half natural size.

Life Form.—Erect perennial herb, perfectly glabrous. Stems thick, succulent, creeping. Roots are emitted at the nodes. Branches erect or ascending, very succulent, sometimes reaching a length of 22 cm. They are perfectly cylindrical.

Leaves small, sessile, in some cases slightly sheathing at the base, 10 13 cm. long. They are fleshy, ovate, have entire margins, and somewhat acute apices.

14. Selliera radicans.

Station.—(1.) H.C.: (*a.*) Overhanging the banks of the channels, where there are long, prostrate, but not rooting, stems, ending in stiff, free branches. (*b.*) Forming a dense matted growth, along with *Salicornia*, in all parts of the salt meadow. (*c.*) On the mud-flats at the edges of the rushes, where it is very luxuriant. (2.) N.Br.: As at H.C. (3.) Tu.: (*a.*) In the meadow, in close mats in the grass. (*b.*) Among the rocks of the railway embankment.

Life Form.—A perennial, perfectly glabrous herb, with yellowish creeping, rooting stems, often being much interlaced, so as to form a thick turf.

Leaves are given off in alternating whorls at the nodes. On the upper part of the free branches they occur singly, though lower down they are again in whorls. They are 4-10 cm. long, spathulate, exstipulate, very fleshy and brittle, with apices acute or sometimes obtuse, margins entire and slightly rolled back. The petiole is not marked off sharply from the lamina, though in the leaves given off from the creeping stems it is rather long. In the salt meadow at Tu., on the other hand, the leaves are almost sessile, though those on the embankment have the ordinary petiole. Again, in the case of the free ascending branches in the masses overhanging the channels at H.C., the upper leaves are practically sessile, their bases slightly clasping the stem (fig. 7, *a*). In the more exposed parts, in the meadows, some of the leaves show beautiful yellow or reddish autumn colouration, a phenomenon somewhat rare in the New Zealand flora. The most brilliant colouring was found in leaves from the embankment at Tu.

Roots are small, white, and sparingly branched.

Mr. Cheeseman has written a very interesting paper on the pollination of the flowers of this species.*

15. Cotula dioica.

Station.—(1.) H.C.: (*a.*) Plentiful in meadows, forming a matted growth. (*b.*) At the edges of the mud-flats. (2.) N.Br.: As at H.C. (3.) Tu.: Out in the meadow among the grasses.

Life Form.—A small, perennial, evergreen herb, with a creeping stem, 3-12 cm. long, rooting at the nodes.

Leaves in tufts, slightly aromatic, rather fleshy, petiolate, exstipulate, and with a membranous sheath at the base. They are very variable in size and shape (fig. 8, *e–h*). They may be spathulate or obovate, crenate, serrate or lobed, sometimes pinnate, the apex being either acute or obtuse. In the lobed forms the lobes may have entire margins or may have irregular serrations towards their apices. As regards size, in the dry parts of the meadow they are from 5–10 mm. long, 2–3 mm. broad (fig. 8, *a*); while in the marshes they may be 4–5 cm. long, 5–12 mm. broad (fig. 8, *c*, *d*). In the more exposed parts of the meadows some of the leaves show a yellow autumn colouration, but it is not of such frequent occurrence nor so brilliant as in *Selliera*. Some of the leaves, however, take on a very peculiar pink colour, as if they had been cut and their cut ends placed in red ink. Flowers were gathered at Tu. as early as July.

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* Trans. N.Z. Inst., vol. ix, p. 542.

Kirk divides *C. dioica* into three species; while Cheeseman gives five varieties of the one species, according to the shape of the leaves. It would be difficult to say to which of these varieties those collected at the above stations belong.

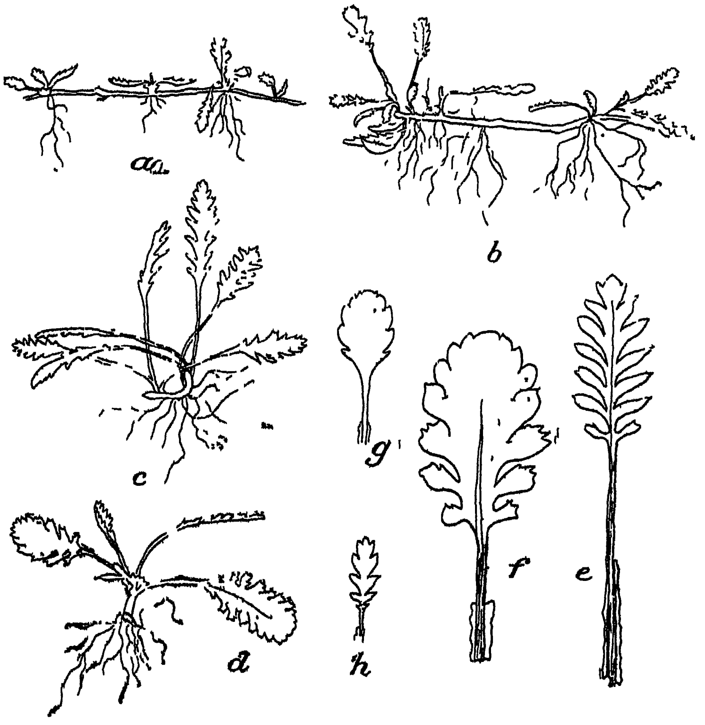

FIG. 8.—COTULA DIOICA.

a. Creeping stem in driest part of salt meadow, half natural size. *b*. Creeping stem in damper part of salt meadow, half natural size. *c*, *d*. Forms from the marsh, half natural size. *e*, *f*. Leaves from salt marsh, natural size. *g*, *h*. Leaves from salt meadow, natural size.

16. Cotula coronopifolia.

Station.—(1.) H.C.: (*a*.) In the salt meadow, where it has stout branches and short leaves. (*b*.) Partly or wholly submerged in the water of the channels. (2.) N.Br.: (*a*.) Salt meadows. (*b*.) Wholly submerged in the brackish water of the pools in the meadows. (3.) Tu.: (*a*) Round the edges of the lagoon. (*b*.) A few individuals actually in the water, but not wholly submerged; this, perhaps, may be accounted for by the fact that the water is exceedingly salt.

Life Form.—(1.) On land (fig. 9, *b*): A perennial, glabrous, evergreen, succulent herb. The stem consists of a short creeping part and ascending or partially prostrate branches, 10–30 cm. long.; they are not much branched, and have short internodes. Leaves (fig. 9, *h*–*k*) are scattered,

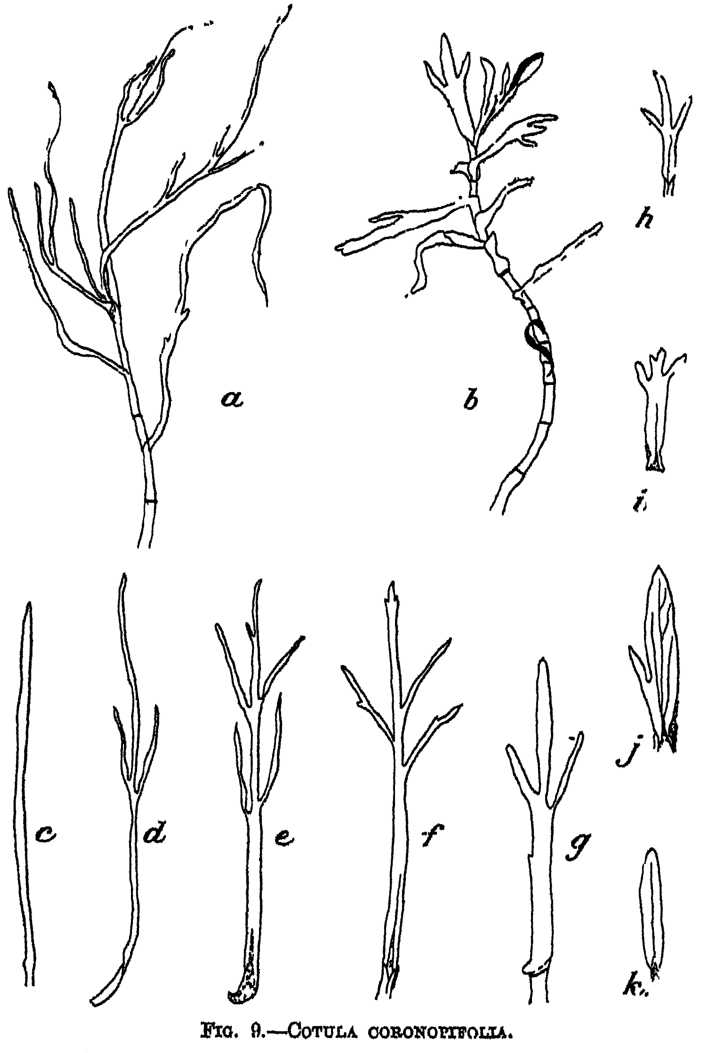

FIG. 9.—COTULA CORONOPIFOLIA.

a. Submerged branch, half natural size. *b.* Branch from damp part of meadow, half natural size. *c, f.* Leaves from submerged plant, half natural size. *g.* Floating leaf, half natural size. *h–k.* Leaves from salt meadow, half natural size.

dilated at the base, and clasping the stem almost the whole length of an internode; they are 3–5 cm. long, 4–12 mm. broad, lanceolate, entire or more or less unevenly toothed; margins are slightly recurved, and apices are generally acute; the mid-rib is rather prominent on the lower surface. Roots fairly short, displaying little secondary branching. (2.) Wholly submerged (fig. 9, *a*): The stems are longer, reaching a length of 40 cm. They are narrower, less rigid, and are generally unbranched. Leaves (fig. 9, *c–f*) also are longer and narrower (9–12 cm. long, 2–5 mm. broad), ribbon-like or finely dissected; they are extremely delicate, so that they droop immediately on being removed from the water. Roots are given off from the nodes right up the stem, except towards the upper end; they are very long, have few rootlets, absolutely no root-hairs, and the upper ones are slightly green.

Fig. 9, *g* shows a floating leaf, which is broader than the submerged ones.

ANATOMY.

No account of the anatomy of the first four species is given, for the reason prefixed to the last section of the paper. With regard to the other species, in most instances the anatomy of the leaf only is described, or of the stem when leaves are absent.

5. Leptocarpus simplex.

Stem.

Epidermis has a cuticle of great thickness. In T.S. this has an apparently cellular structure (fig. 10, *a*), but, as it assumes a yellowish-brown colour with chlor-zinc-iodide, it is assumed that cutin is present. Then, again, by taking longitudinal sections, it is seen that the apparently cellular structure is due to irregularity in the laying-down of the thickening layers, each of which has a wavy outline (fig. 10, *b*).

The stomata occur over the bands of chlorenchyma, and are small, and sunk below the rest of the epidermis. In T.S. two small subsidiary cells appear. In most cases the edges of the cuticle almost meet over them, so that they can scarcely be seen in surface-view.

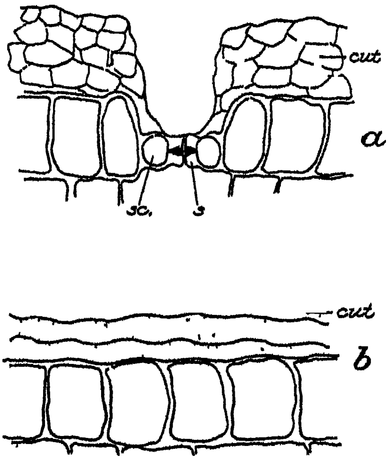

FIG. 10.—LEPTOCARPUS SIMPLEX.

a. T.S. of epidermis, showing cuticle; highly magnified. *b.* L.S. of epidermis showing cuticle; highly magnified.

Chlorenchyma in definite bands 3–4 layers deep, and 6–7 cells wide. The cells are of the regular palisadic type, with somewhat numerous and rather large chromatophores.

Sclerenchyma: Narrow bands of thick-walled cells, alternating with the bands of chlorenchyma.

The f.v. bundles are in three fairly regular circles, the larger ones towards the inside, while the outermost circle is formed of tiny bundles, one beneath each band of sclerenchyma. Each bundle has a mass of sclerenchyma at its upper end, and this sclerenchyma is continued round to form a complete circle, in which the outer bundles are embedded. There is a small amount of phloem in the bundle, and a xylem with conspicuous annular vessels. Round the whole cylinder is a well-marked pericycle, interrupted at each band of sclerenchyma.

The pith consists of—(1) a tissue of thick-walled cells, rich in starch, evidently assisting in giving rigidity to the stem; (2) the pith proper of large polygonal cells, thin-walled, with few and very small intercellular spaces.

6. Juncus maritimus, var. australiensis.

Stem.

Epidermis with cells of the ordinary type, though rather smaller, and without stomata above the bands of sclerenchyma. The stomata are not sunk in the epidermis, as in the case of *Leptocarpus*. In surface-view the guard-cells are long and narrow, with very much thickened inner walls.

Chlorenchyma consisting of bands 5-6 layers deep. There are numerous small ellipsoidal chlorophyll grains.

Sclerenchyma of narrow, much elongated cells, in narrow bands between the bands of chlorenchyma. Each band is continued to join the sclerenchyma on the outer side of the f.v. bundle immediately beneath.

The f.v. bundles are numerous, and scattered through the pith in very irregular circles. Each has a well-marked bundle-sheath.

The pith is large, and consists of rounded, thin-walled cells, with intercellular spaces of ordinary size. There are also larger lysigenic air-spaces specially towards the outer part of the pith. The schizogenic spaces are smaller than those of most rushes (*e.g.*, in the characteristic stellate parenchyma of *J. conglomeratus*).

7. Atriplex patula.

Leaf.

Epidermis: The cuticle is not thick, and stomata are found on both surfaces. They are not numerous, and have small guard-cells slightly below the level of the other cells. Anthocyan is found in many of the cells. The epidermal cells immediately above and below the midrid are smaller, and have thicker division-walls than the rest of the epidermal cells. Shrunken, dead hairs cover the epidermis.

Mesophyll is formed of palisadic cells, 6-8 layers, with very small intercellular spaces, and small rather scanty chlorophyll grains. Surrounding the midrib is a large mass of colourless parenchymatous cells, polygonal in outline, though those towards the upper surafce are somewhat elongated. They are thin-walled, with the exception of 2-3 layers adjacent to either epidermis.

The midrib is very prominent, and is composed of 4 conspicuous bundles, embedded in a mass of thick-walled cells, and with sclerenchyma at their outer limits.

Stem.

As the stem is of a rather anomalous structure, a short account of it may be given here. Sections were cut and stained very successfully with saffranin and methyl blue. The saffranin picked out cortex, pith, and phloem, while the wood took on an intense blue stain. In section, 4 primary and 4 secondary ridges appear.

Epidermis: In T.S. the cells on the ridges appear smaller; but in surface-view they are longer and narrower than those in the grooves. Stomata are confined to the grooves, and anthocyan is found only in the cells of the ridges.

Cortex of thin-walled hexagonal cells, some of which contain crystals. On the ridges it is modified to form a thick-wall strengthening tissue of small cells, and in the grooves 2–3 layers of chlorenchyma, recalling the structure of the cortex of *Equisetum*.

The f.v. bundles are very anomalous in structure. According to De Bary (i, p. 590–95), "There is first a primary ring of bundles, leaf trace, and perhaps intercalary as well. While the development of these is still proceeding, round the outer margins of their phloems an extra fascicular ring of cambium appears, and forms on its inner side alternately vascular bundles and intermediate tissue; on its outer side, a thin layer of bast parenchyma, or none at all." The intermediate tissue in sections examined seems to have formed a wide layer of wood, which in L.S. appears to consist of tough, fibrous elements. The xylem of the small collateral bundles can be recognised among the intermediate tissue by its thicker walls and larger lumina. The phloem forms small groups interrupting the cambium ring, while further out are groups of thick-walled cells (staining blue), perhaps formed from a second ring of extrafascicular cambium.

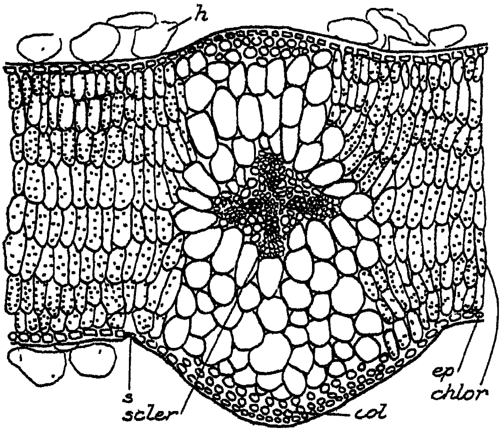

FIG. 11.—ATRIPLEX PATULA.

T.S. leaf, × 55.

The pith is large, and consists of rounded, thin-walled cells, some with crystals.

8. Salicornia australis.

Stem (Fig. 2, *b*).

Epidermis: A single layer of cells with a slightly thickened cuticle. The stomata are rather numerous, of medium size, narrow slitted, and not sunk beneath the general surface, though Warming (v, p. 216) says they have been so described. In surface-view the epidermal cells have a regular polygonal outline.

Palisade tissue 2–3 cells thick. In T.S. the cells are long, very narrow, closely packed, and contain numerous small rounded chromatophores.

Water-bearing tissue occupies the greater part of the stem. The cells are polygonal, thin-walled, contain no chromatophores, and have very small intercellular spaces. Towards the outer limits of this tissue there are bundles of tracheides with spiral markings, forming a broken ring parallel with the epidermis. According to De Bary (i) there are scattered tracheides in *Salicornia herbacea;* but they occur in the chlorophyll tissue, and are "perpendicular" to the epidermal cells. Warming (v, p. 215) mentions similar tracheides in the green tissue of *Salicornia herbacea.* It is thought by some authorities that these tracheides serve the purpose of air-storing (xi, 357).

The central cylinder is of a rather anomalous character There is a well marked endodermis beneath which are 2 3 layers of thin walled cells followed by bead like rows of cells, and these in all cases were found to contain green chromatophores which seems very remarkable in such a deeply seated tissue Next are 2–3 layers of thin walled cells, evidently an extra fascicular cambium such as De Bary describes in *S herbacea* and on the inner side of this cambium ring and evidently formed from it is a zone of xylem, enclosing a pith containing the original collateral bundles In the centre is a small medullary cavity

9 Spergularia media.

Leaf

Epidermis (fig 12, *b*) consists of cells with wavy outline, the cuticle being thin, but marked with fine striations Stomata are rather numerous on both surfaces Peculiar hairs terminated by rounded knobs perhaps function as hydathodes (fig 12 *c*)

Mesophyll (*a*) On the upper side are 4 layers of palisade cells with numerous chlorophyll grains some contain masses of crystals some contain anthocyan, though this is not present in the epidermis (*b*) Colourless parenchyma of thin walled cells, polygonal, or somewhat rounded in outline, with few and small intercellular spaces , in some cases this occupies about half the width of the leaf and more than one third of its thickness , masses of crystals are found here also

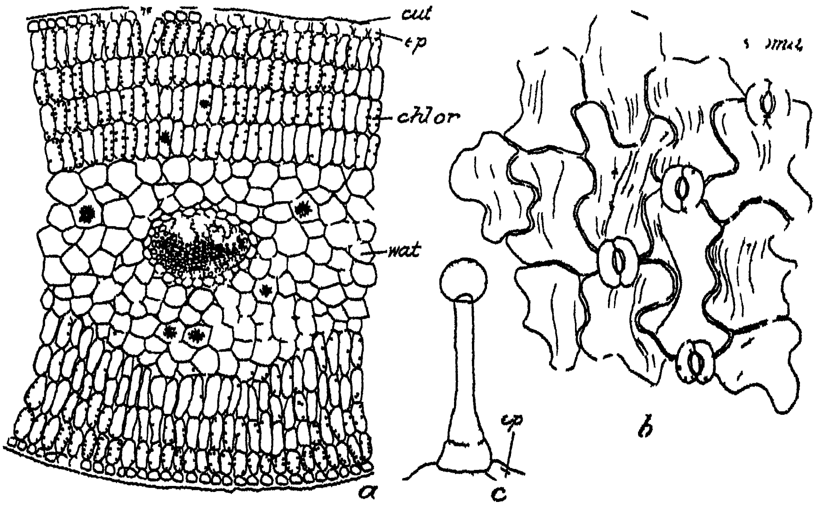

Fig 12 —Spergularia media

a T S leaf, × 32 *b* Surface view of epidermis of leaf *c*. Hair from leaf

The midrib has a well-marked sheath The xylem is very prominent, but there is little phloem. The whole is embedded in a mass of sclerenchyma.

10. Plagianthus divaricatus.

Leaf.

Epidermis with cells of the ordinary type and a thin cuticle. The stomata are equally numerous on both surfaces, but are not sunk in the epidermis. On the lower side of the leaf are curious stellate hairs (fig. 4), evidently secreting the slimy excretion found on the leaves.

Mesophyll.—(*a*.) Palisade parenchyma in 3 layers, 2 of closely packed cells and a third of cells with larger intercellular spaces; the chlorophyll grains are small, but rather numerous. (*b*.) Spongy parenchyma is largely developed, occupying two-thirds of the mesophyll; the cells are elongated, and the intercellular spaces, though large, are not so large as those of typical spongy parenchyma; the lowest layer next the lower epidermis is of shorter more regular cells; the chlorophyll grains are almost as numerous as in (*a*), though, of course, there are fewer towards the central part of the leaf.

Midrib has a sheath of regular cells and a well-marked phloem. Above and below it, reaching to either epidermis, are colourless cells of the mesophyll.

11. Apium prostratum.

Leaf.

Epidermis consists of small cells with quite thin cuticle. Stomata are numerous though small, and occur only on the under-surface.

Mesophyll.—Two layers of much elongated palisade cells with small, not very numerous, chlorophyll grains. The intercellular spaces are small, and not frequent. This palisade tissue constitutes three-quarters of the entire mesophyll. The inner layer has shorter cells and fewer chromatophores than the outer.

Vascular bundles are small, with prominent sheath and no sclerenchyma. Fig. 5, *d*, shows one of the smaller veins, not the midrib.

12. Samolus repens.

Leaf.

The epidermis consists of cells rather polygonal in outline, with somewhat thickened outer walls and cuticle. Each cell contains a very conspicuous drop of oil, soluble in ether. The stomata are as numerous on the upper as on the lower side. In the upper epidermis some of the cells have a pinkish hue, due to the presence of anthocyan. This is not found, however, in the cells of the lower epidermis. On both surfaces of the leaf tiny pores are visible to the naked eye. Microscopically examined, in surface-view, these appear as rounded openings, sometimes with apparent cell-walls radiating from the centre. In T.S. (fig. 13, *b*) it is seen that these are not breaks, but invaginations in the epidermal wall. Most of these are filled with greenish grains of wax, which also appear in patches elsewhere on the surface of the leaf. This wax is soluble in ether. In some cases a few very small spherical green algæ were found in the wax. At the bottom of each pit is a glandular hair (fig. 13, *b*). The hair is divided by vertical walls into several cells, supported on a swollen basal cell, evidently but a modified epidermal cell. The cells of the epidermis lining the cavity are somewhat elongated. Warming (v, p. 185) mentions and figures similar glandular hairs ("*kirtelhaar*") in *Glaux maritima*, and notes that Kamienski represents them in *Samolus littoralis*. The hairs in *S. repens* are very like those figured by Miss Ewart (iv) in *Ipomœa paniculata*. They have the same swollen, supporting basal cell, and the same vertical divisions, though they are in simple pits, not in the elaborate crypts of *Ipomœa*. Warming (v, p. 193), too, describes glandular hairs in *Ipomœa pes-capræ*.

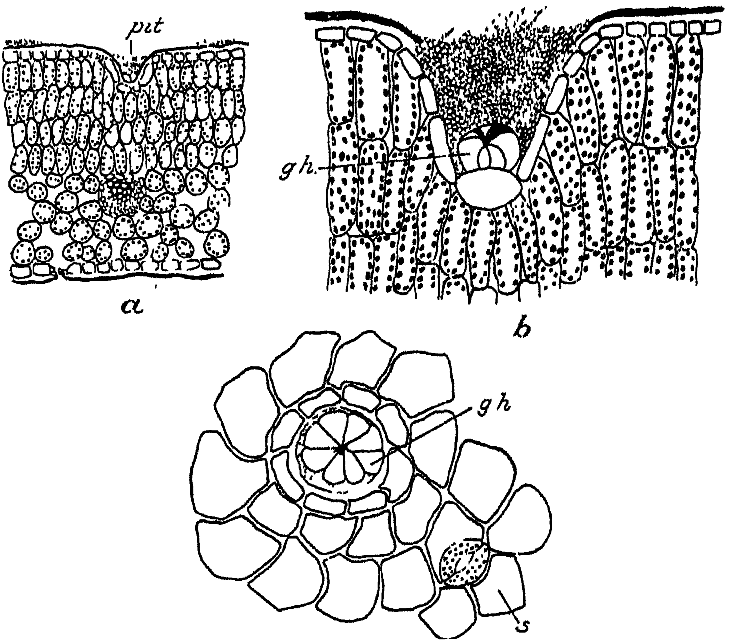

FIG. 13.—SAMOLUS REPENS.
a. T.S. leaf of *b*, × 60. *b.* Pit with glandular hair, highly magnified. *c.* Surface-view of pit with glandular hair, highly magnified.

He gives it as his opinion that these hairs, as well as those of *Glaux maritima*, function as hydathodes (v. p. 240).

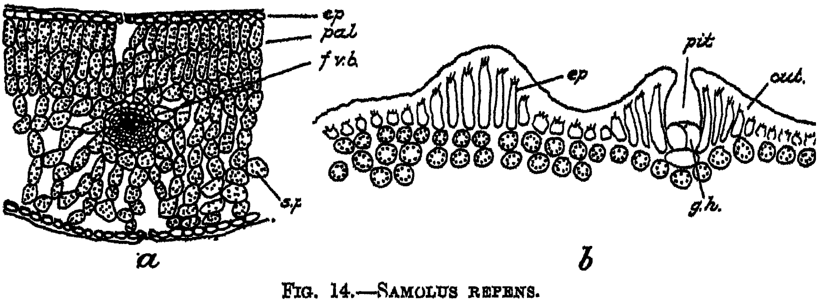

FIG. 14.—SAMOLUS REPENS.
a. T.S. leaf of var. *stricta* (?), × 60. *b.* T.S. epidermis of stem, showing pit with glandular hair; highly magnified.

Mesophyll: (*a.*) Palisade parenchyma consists of 4 rows of cells, about twice as long as they are wide. The chlorophyll grains are small, rather numerous, and ellipsoidal in shape. (*b.*) Spongy parenchyma, 3 irregular layers with large intercellular spaces; the cells contain few chromatophores.

Midrib is small, with definite endodermis, the "starch-sheath" of Brick.

Sections of the stem (fig. 14, *b*) were cut also to investigate the cause of its roughness. It was found that this is due to little projections on the surface, each of which is depressed in the centre to form a deep pit containing a glandular hair, similar to those found on the leaves. All the walls of the epidermis are thickened, the outer one being thickly cuticularised. The cells themselves have curious prolongations towards the outer surface. Each one contains a large drop of oil.

14. Selliera radicans.

The anatomy of two forms of leaf is described: (*a.*) From the free ascending branches of plants overhanging the channels; these leaves have an average thickness of 1 mm. (*b.*) From the creeping stems on the salt meadows; here the average thickness is 2 mm.

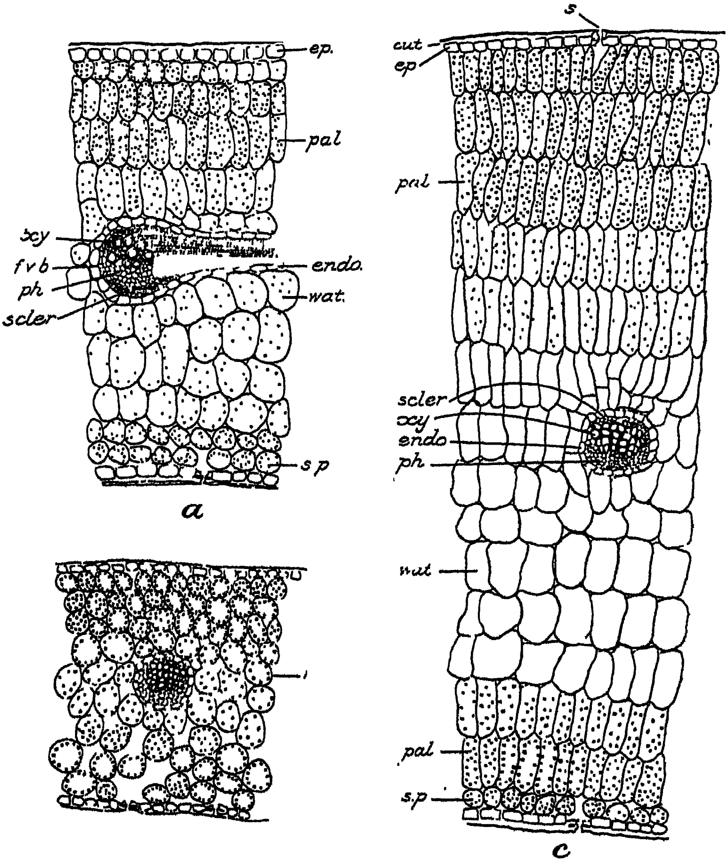

FIG. 15.—SELLIERA RADICANS.
a. T.S. of *b* in fig. 6, × 55. *b.* T.S. of leaf from plant growing in pot, × 55.
c. T.S. of *d* in fig. 6, × 55.

Epidermis on both upper and lower sides has somewhat thickened outer walls and cuticle. Some of the cells of the upper epidermis contain anthocyan. Stomata are of medium size, or rather large, and equally numerous on both surfaces. They are not sunk in the epidermis. The guard-cells have conspicuous chlorophyll grains.

Mesophyll: (*a.*) A single layer of rounded, closely packed cells, with comparatively numerous chlorophyll grains. (*b.*) 2–3 layers of typical palisade parenchyma, of very closely packed cells. (*c.*) 3–4 layers of large, irregular cells, with small intercellular spaces and very few chromatophores. (*d.*) 2 layers of smaller, rounded cells, with larger spaces, forming a kind of reduced spongy parenchyma.

The midrib has a well-marked endodermis, and an upper and lower band of sclerenchyma.

15. Cotula dioica.

Leaf.

Epidermis has a thin cuticle, marked with delicate striations. On both surfaces are pits with glandular hairs. Each hair consists of 3–4 short basal cells, with abundant dark contents, and a narrow terminal cell with clear contents. The hairs are much longer on the lower surface than on the upper, and not situated in such deep pits. Stomata are equally numerous on both surfaces. They are large, with guard-cells containing very conspicuous large spherical chromatophores, found constantly arranged in a definite way, lining the inner wall of the cell.

Mesophyll: (*a.*) 3 layers of irregular, somewhat short cells, with few, but very large, ellipsoidal chromatophores. (*b.*) 4–5 layers of large polygonal cells with few chromatophores, and few very small intercellular spaces; this probably functions as a water-bearing tissue. (*c.*) 2–3 layers of cells, with chromatophores almost as numerous as in *a*; this constitutes a kind of spongy parenchyma of rounded cells, loosely arranged. The lowest row is of smaller more regular cells.

The midrib is fairly large, and has a mass of colourless small-celled parenchyma above and below, though there is no distinct endodermis. The xylem is very conspicuous, the vessels being arranged in parallel rows.

16. Cotula coronopifolia.

Leaf (A, *from Salt Meadows*; B, *Submerged*).

A.—Epidermis has slightly thickened outer walls and cuticle. It is marked with fine striations (*cf. C. dioica*). The stomata are equally numerous on either surface. They are not so large as those of *C. dioica*, and in surface-view (fig. 16, *d*) are seen to be slightly overarched by neighbouring epidermal cells. On both surfaces are peculiar pointed multicellular glandular hairs, recalling those of *C. dioica*, though they are not situated in depressions.

Mesophyll: (*a.*) 3 layers of rounded, closely packed, regular cells, with large but not numerous chromatophores. (*b.*) 10–12 irregular layers of rounded cells with few chlorophyll grains and large intercellular spaces. (*c.*) A single layer of closely packed ellipsoidal cells, with chromatophores as numerous as those in *a*.

Midrib has a prominent sheath, well-marked xylem, and little phloem, embedded in sclerenchyma. There are 2 or 3 layers of colourless parenchymatous cells surrounding the midrib.

B.—The leaf (fig. 16, *c*) here is about half as thick as in A. The same figures and letters are used as in A, and only points of difference are noted.

Epidermis is not cuticularised, and no striations appear on the surface. The epidermal cells are elongated in a direction parallel with the longitudinal axis. There are very few stomata.

Mesophyll: (*a.*) There are only 2 layers of closely packed cells. (*b.*) Only 5–6 layers of loose mesophyll, and the spaces are larger and more numerous. (*c.*) 2 layers of closely packed cells similar to those in (*a*), so that the structure of both sides of the leaf is the same, as might be expected in a submerged plant.

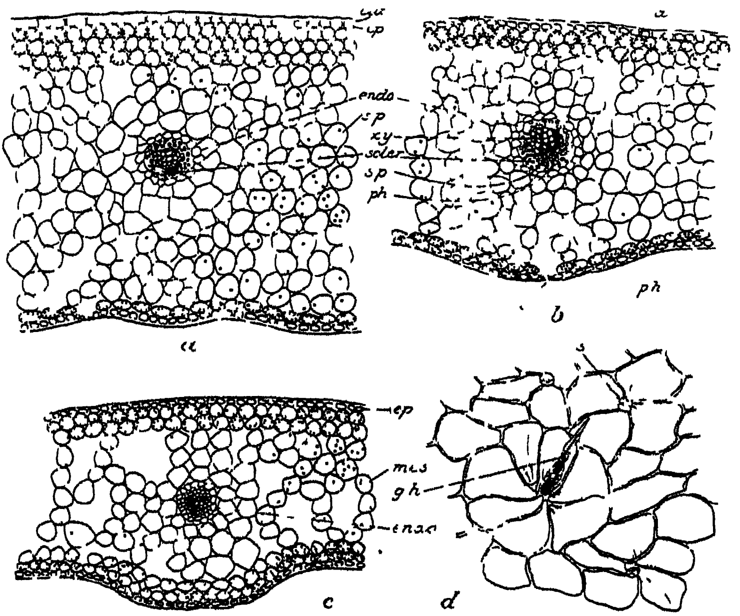

Fig. 16.—Cotula coronopifolia.

a. T.S. leaf from meadow, × 55. *b.* T.S. leaf from plant grown in a pot, × 55. *c* T.S. submerged leaf, × 55. *d.* Surface-view of upper epidermis of leaf *c*, Fig. 9, highly magnified.

The midrib is smaller, has a more prominent phloem, and the xylem elements have not such thickened walls. There is no scleronchyma.

Comparison of Plants grown at Canterbury College with those from their Natural Habitat.

The following plants were planted at Canterbury College, some in the flower-beds and some in the greenhouse :—

1. *Salicornia australis.*
2. *Spergularia media.*
3. *Apium prostratum.*
4. *Samolus repens.*
5. *Selliera radicans.*
6. *Cotula dioica.*
7. *Cotula coronopifolia.*

These were planted on the 1st April, and their leaves examined anatomically towards the end of September. Of those in the open flower-beds, none flourished except *Cotula coronopifolia;* but all those planted in the greenhouse with the exception of *Salicornia* grew splendidly. They were plentifully watered with fresh water, but the greenhouse was not artificially heated in any way.

They were found to differ in general appearance from plants from their natural habitat in the following points: (1) They were less compact and less stunted in habit; (2) their leaves were much thinner; (3) their leaves had a brighter green colour.

1. Salicornia australis.

This appeared to die at once, not one little green shoot remaining; but it was watered with the rest, and early in October tiny green shoots appeared on the dry stems.

2. Spergularia media.

The plants lost their cushion-like habit, and developed long, straggling branches, with longer and more flattened leaves. On an average, the leaves were four-fifths of the thickness of those from the meadows.

Anatomical Differences in Leaf.—There was no decrease in the number of layers, though all the cells of the mesophyll were somewhat smaller. The chlorophyll grains were not more numerous, but were larger. The cuticle had no markings on its surface, and this was no doubt due to the fact that the plants were not exposed to such strong insolation.

3. Apium prostratum.

This species grew very vigorously, and on comparing the leaves, first with some which had been in spirit since the 1st April, and then with leaves of plants which were at about the same stage in the natural habit, it was found that their thickness was, on an average, only half that of the other two. Sections being examined, it appeared that this decrease in thickness was due not to a lessened number of layers, but to a diminution in the size of the cells of the palisadic tissue. In all cases the depth of the two layers was less than one-third of that of the corresponding layers in those which had grown in the channels. The spongy parenchyma was as well developed in one case as in the other.

The midrib showed no decrease in size corresponding to the diminished thickness of the whole leaf.

4. Samolus repens.

(1.) *Leaves of Plants grown in the Greenhouse.*—These on an average were but half the thickness of those from the natural habitat. This was due both to reduction in the number of palisadic layers, only three being found, and to a reduction also in their size. There did not appear to be any increase in the number of chlorophyll grains.

(2.) *Leaf of var.* stricta (fig. 14, *a*).—This showed the following differences from that of the ordinary variety from the salt marsh, though it was of the same thickness:—

Epidermis: The outer walls were not so thick or so distinctly cuticularised, and the deposit of wax was less.

Mesophyll: On the whole, there was less differentiation of the tissues. (*a*.) Palisadic parenchyma—3 layers only, and these arranged less regularly, with greater intercellular spaces; the chlorophyll grains were slightly more numerous but not so large. (*b*.) Spongy parenchyma greatly developed, and with somewhat elongated cells.

5. Selliera radicans.

The leaves (fig. 15, *b*) were compared with those on ascending branches (fig. 15, *a*), and were found to be but half their thickness, decrease in size being due to decrease both in the number of layers of cells and in their size. Towards the upper surface, instead of palisade cells there were 3–4 layers of rounded rather closely packed cells, while beneath there were 5–6 irregular layers of somewhat larger rounded cells, with greater intercellular spaces. The chlorophyll bodies were not more numerous, but somewhat larger. The cuticle was much thinner.

6. Cotula dioica.

This species showed very little change, though the leaves were slightly thinner. There was no decrease in the number of layers, though the cells were in some cases somewhat shorter.

7. Cotula coronopifolia.

Leaf (Fig. 16, *b*).

Epidermis had somewhat thinner cuticle.

The palisade parenchyma showed only two rows of closely packed cells, and in most cases the chlorophyll grains were slightly larger, though not more numerous.

The spongy parenchyma was scarcely so well developed, but had rather more intercellular spaces. Probably in the typical halophytic form this may be largely developed to form a water-bearing tissue.

Not too much confidence is placed in these results, as the decrease in thickness in so short a time seems too great to be accounted for by the absence of salt in the soil only. Very probably it was to some extent due to other external conditions, such as their being grown within doors and in pots. Had this comparison been intended for the chief section of the work, time would have been taken to repeat Lesage's classical experiment, and so to confirm the above results. In any case, it must be assumed that the absence of salt in the soil is the principal cause of the decrease in the thickness of the leaves. Then, again, as Lesage found during his experiments, this decrease is due to a lessening of the number of the palisadic layers, or to a diminution of the size of their cells, or to both.

GENERAL CONCLUSIONS.

In the first place, with regard to the life form and external morphology of these New Zealand halophytes, they exhibit, on the whole, the following characteristics:—

(1.) A tendency to adopt a prostrate habit (*Atriplex*, *Selliera*), and to present a more or less stunted appearance (*Plagianthus*). Several explanations have been put forward to account for this stunted condition.

Schimper (x) attributes it to the superabundance of salt in the soil; Warming (v) to an attempt to reduce the transpiring surface. Dr. Cockayne, in his general account of the coastal vegetation of the South Island of New Zealand, points out that the wind must be an important factor.* This seems to be confirmed by the fact that those plants of the salt meadows which have strayed into the marshes, or occupy the channels and are sheltered by the dense growth of rushes or by the *Plagianthus* bushes, have discarded to some extent the prostrate habit (*e.g.*, *Atriplex*, *Selliera*). The direction of the prevailing wind is shown by the bushes of *Plagianthus*, which in the more exposed situations are bent towards the west. It is a well-known fact, however, that excess of light is not conducive to growth; and here on the salt meadows there is a very bright illumination. May not this account, in some degree, for the stunted growth?

(2.) A reduction of the leaves, both as regards number and size (*Plagianthus*). In *Salicornia* they are entirely absent, while in *Leptocarpus* and *Juncus* they are reduced to scales. This must be accounted for, as it generally is, as a modification to reduce the transpiring surface. In the case of *Plagianthus*, however, the wind, again, may be a determining factor in the leaf-reduction, as well as in the adoption of a twiggy divaricating habit.

(3.) A more or less brilliant colouration, especially in the autumn, and this in plants which are not deciduous (*Selliera*, *Cotula dioica*). The colour here evidently is due, as Ganong (XI, p. 355) suggests, to the amount of salt in the soil. Again, some exhibit a reddish colour, due to the presence of anthocyan in the cells (*Atriplex*, *Spergularia*, *&c.*). Many theories have been advanced as to the use of this pigment, one being that it acts as a screen to the chloroplasts, to preserve them from injury from too intense light (VII, p. 282). This would seem a very satisfactory explanation as far as these halophytes are concerned, for on the level unshaded salt meadows they are subjected to strong insolation.

(4.) A great thickness of the leaves. This, perhaps, is the most noteworthy of these characteristics, and will be dealt with more fully under anatomical characters.

(5.) Translucence of the leaves (*e.g.*, *Selliera*, *Spergularia*).

Some authors (*i.e.*, Henslow, and Battandier, whom he quotes) give hairiness as a very general character of halophytic plants; but none of these New Zealand halophytes show any hairiness, except *Atriplex*, with its mealy tomentum of dead hairs, and *Spergularia*, with its sparse covering of white hairs, almost invisible to the naked eye.

ANATOMICAL CHARACTERS OF THE LEAF.

Epidermis: In some cases this shows a very much thickened cuticle (*Leptocarpus*); but, on the whole, it is not strongly developed. The cuticle often has an uneven surface, which in one case (*Spergularia*) became smooth when plants were grown in pots. In all probability this uneven cuticle is a definite adaptation, to guard the leaf against the effect of the strong insolation. In connection with the epidermis, again, glandular hairs are developed (*Plagianthus*, both species of *Cotula*, *Samolus*, *Spergularia*). These are said to function as hydathodes (v). Stomata are rather large, and occur on both surfaces. This last observation does not lend support to the generally accepted view that halophytes exhibit a xerophytic structure. Chrysler (XIV, p. 463) also notes the presence of stomata on both surfaces in maritime plants. However, this may be due in some cases (*i.e.*, *Atriplex*) to the more or less vertical position of the leaves. Again, in very few instances are stomata sunk beneath the general surface of the epidermis; but it would be unreasonable to argue from this that these plants do not show a xerophytic structure, as even the most typical xerophytes do not exhibit every single one of the strictly xerophytic adaptations.

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* This, of course, chiefly works by its physiological effect in transpiration, leading to death through drying-up of tissues. There is also a mechanical effect.

Mesophyll shows the following characteristics: (*a.*) A great development of palisadic tissue, a remarkably xerophytic character, resulting in the checking of too rapid transpiration. (*b.*) A corresponding reduction of the spongy parenchyma. (*c.*) In some cases a development of a definite water-bearing tissue (*Cotula coronopifolia*, *Selliera*, and the stems of *Salicornia*). (*d.*) A great reduction of the intercellular spaces; and no doubt to this is due the translucence of the leaves; this reduction causes a diminishing of the transpiring surface. (*e.*) In some cases chlorophyll grains are few; by experiment it was found that the size of the grains, rather than their number, increased when plants were cultivated away from their native habitat. (*f.*) The vascular system is not particularly well developed. (*g.*) A definite endodermis is almost invariably present, as Brick, who calls it the "starch-sheath," found in many maritime plants.

ORIGIN OF THE HALOPHYTIC FORMATIONS.

Many of the above characters are plainly those of xerophytes, the main object being to reduce the transpiring surface. *Cotula coronopifolia*, however, shows scarcely any of these xerophytic characters, for it has no true palisadic tissue in its leaves, and it has large intercellular spaces in both leaves and stem. This latter fact, above all, would lead to the conclusion that this plant was primarily an aquatic plant, able to frequent brackish-water pools, and that from these it has crept up into the meadows, where it has undergone a few modifications, such as the formation of a water-bearing tissue, to cause it to flourish as it does in its new environment.

Again, *Plagianthus* certainly exhibits characters essentially xerophytic, and is of a type very similar to typical New Zealand xerophytes (*i.e.*, *Coprosmas*). The question to be considered here is whether its xerophytic characters are to be regarded as results of a direct adaptation to its present environment, or whether, primarily a xerophyte, it found those modifications which fitted it for its life as a xerophyte equally useful in its new surroundings. If this latter supposition be correct, it may be said that these halophytic formations have a threefold origin—*i.e.*, from hydrophytes (*Cotula coronopifolia*), xerophytes, and lastly mesophytes, for many of them are to be found inland in typical mesophytic formations (*Cotula dioica*, *Selliera radicans*). Schimper, however, defines halophytes as "salt-enduring xerophytes driven to the shore by competition." In any case, we must agree that these are very probably "ordinary inland plants which have been driven out of the more hospitable ground by better-equipped competitors," and that they "occupy their peculiar station not from choice, but from necessity" (XIX), for when transferred to ordinary soil they grow luxuriantly, while many are found inland.

LETTERING USED IN FIGURES.

a.s.	.. air-space	*mes.*	.. mesophyll.
antho.	.. anthocyan.	*p.*	.. pith.
cam.	.. cambium.	*pal.*	.. palisade parenchyma.
cent. cy.	.. central cylinder.	*ph.*	.. phloem.
chlor.	.. chlorenchyma.	*pr.b.*	.. primary bundle.
col.	.. collenchyma.	*s.*	.. stoma.
cr.	.. crystals.	*s.c.*	.. subsidiary cell.
cut.	.. cuticle.	*scler.*	.. sclerenchyma.
endo.	.. endodermis.	*s.p.*	.. spongy parenchyma.
ep.	.. epidermis.	*st.*	.. stereom tissue.
g.h.	.. glandular hair.	*wat.*	.. water bearing tissue.
h	.. hair.	*xy.*	.. xylem.

BIBLIOGRAPHY.

I. A. De Bary: "Comparative Anatomy of the Vegetative Organs of the Phanerogams and Ferns." 1884.
II. P. Lesage: "Influence du bord de la mer sur la Structure des feuilles." 1890.
III. Henslow: "Origin of Plant Structures." 1895.
IV. M. F. Ewart: "On the Leaf-glands of *Ipomœa paniculata*" (Annals of Botany). 1895.
V. E. Warming: "Halofyt-Studier." 1897.
VI. K. Goebel: "Organography of Plants." 1900.
VII. J. R. Green: "Vegetable Physiology." 1900.
VIII. Warming: "Pflanzengeographie." 1902.
IX. K. Smalian: "Lehrbuch der Pflanzenkunde fur Hohere Lehranstalten." 1903.
X. A. F. W. Schimper: "Plant Geography." Translated by W. R. Fisher. 1903.
XI. W. F. Ganong: "The Vegetation of the Bay of Fundy Salt and Diked Marshes." 1903.
XII. E. Strasburger: "Text-book of Botany." Translated by H. C. Porter. 1903.
XIII. T. H. Kearney: "Are Plants of Sea-beaches and Dunes true Halophytes?" (Bot. Gazette, xxxvii, 424–36). 1904.
XIV. M. A. Chrysler: "Anatomical Notes on certain Strand Plants." (Contributions from the Hull Botanical Laboratory, lviii.) 1904.
XV. C. J. Chamberlain: "Methods in Plant Histology." 1905.
XVI. Laing and Blackwell: "Plants of New Zealand." 1906.
XVII. Cheeseman: "Manual of the New Zealand Flora." 1906.
XVIII. D. T. MacDougall: "The Delta of the Rio Colorado." 1906.
XIX. L. Cockayne: "Some Observations on the Coastal Vegetation of the South Island: Part I." (Trans. N.Z. Inst., vol. xxxix.) 1907.
XX. T. G. Hill: "Observations of the Osmotic Properties of the Root-hairs of certain Salt-marsh Plants." ("New Phytologist," Nos. 6 and 7.) 1908.

ART. LVIII.—*On the Glacial Till in Hautapu Valley, Rangitikei, Wellington.*

By Professor JAMES PARK, F.G.S.

[*Read before the Otago Institute, 10th August, 1909.*]

I WISH to bring under the notice of the Society some important evidence of ancient glaciation I have recently discovered in the western portion of the Province of Wellington. The general geological structure and physiographical features of this region are as follows:—

The triangular area lying between the Manawatu River and Wanganui is occupied by a gravel drift 400 ft. or 500 ft. thick. Along its inland border this drift rests against a series of marine clays of Pliocene age that are horizontal or dip gently towards the sea. These clays, which are commonly known by the Maori name "papa," extend northward to the flanks of the Kaimanawa Mountains, along their northern limit skirting the upland plains that wrap around Ruapehu. In a few places they are intercalated with thin beds of shelly limestone, or contain irregular layers of hard calcareous nodules.

The gravel drift forms the coastal plain, which is now highly cultivated; but north of this the papa country is broken into hills and ridges, which are covered with a dense forest. Inland of the forest-belt, which is forty or fifty miles wide and runs parallel with the coast-line, the country is undulating grass land.

The Kaimanawa Mountains, from 4,500 ft. to 6,000 ft. high, are drained by the Rangitikei River and its tributary the Moawhango; and the papa country, going westward, by the Hautapu, Turakina, and Wangaehu, the first a branch of the Rangitikei. These rivers rise in the inland treeless country, traverse the forest-covered papa lands, and all, except the Hautapu and Moawhango, flow across the coastal plain, in which they have excavated deep channels with vertical banks. The Wangaehu River drains the south-east slopes of Ruapehu, from 7,500 ft. to 9,000 ft. high, rising in the glacier occupying the crater of that mountain.

Beginning at Waiouru, situated on the inland grass lands, and thence proceeding eastward across the ridges dividing the Wangaehu from the Hautapu, the hills are found to present the smooth-flowing outlines, truncated crests, and terraced slopes characteristic of glacial erosion. Many of the higher hills are domed, while the low hills are hummocky and whale-backed in form. At Taihape the hills are beautifully rounded, coned, and domed, and at Mataroa there is a fine example of a U-shaped valley. The evidences of ice erosion are also conspicuous both in the upper and lower Rangitikei.

During a recent examination of this region I also found that a large stretch of country, beginning at Karioi, near the foot of Ruapehu, and extending across the dividing-ridges into the Hautapu Valley, was covered with a sheet of glacial boulder-clay or till.

The till consists of clays, or of clays mixed with andesite blocks, or of andesite blocks containing little or no clay. It is generally unstratified, but in a few places layers of boulders are interbedded with bands of clay. The boulders range from small blocks up to masses 6 ft. and 8 ft. in diameter. They are always angular or semiangular, the latter being the result of weathering. Water-worn material is present in some places, but never comprises more than a small proportion of the material. The number of very large blocks of andesite increases in proceeding down the valley, masses over 6 ft. in diameter being more plentiful between Mataroa and Taihape than elsewhere.

The thickness of the till varies from 0 ft. to 60 ft., so far as can be seen in the road and railway cuttings, but it may possibly exceed 60 ft. In many places the till rests on the summit of hills 300 ft. and 400 ft. above the floor of the old glacial valley, and in these situations it is impossible to determine the actual thickness.

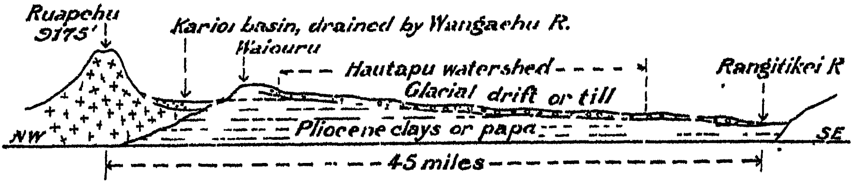

FIG. 1.—SECTION FROM RUAPEHU ACROSS KARIOI BASIN, DRAINED BY WANGAEHU RIVER, TO RANGITIKEI VALLEY, SHOWING DISTRIBUTION OF GLACIAL TILL.

On the Karioi side of the divide the till is mainly composed of clays; but on the Waiouru plateau, at a height of 2,660 ft. above the sea, andesite blocks are in places present in large numbers.

From the 244-mile mark onward, passing down the Hautapu Valley, blocks become more and more abundant until Taihape is reached, beyond which the clays predominate.

As measured along the railway-line, the till extends down the Hautapu Valley for a distance of some twenty-six miles, ending near Utiku at a height of 1,220 ft. above the sea. Altogether the andesite blocks at the southern limit of the till have travelled some forty-five miles from their source at Ruapehu. The width of ground over which they are spread, so far as the clearing of the forest will permit examination, is found to vary from two to five miles.

Good sections of the till are exposed in the shallow railway-cuttings a short distance west of Waiouru Railway-station, and in the deep cuttings

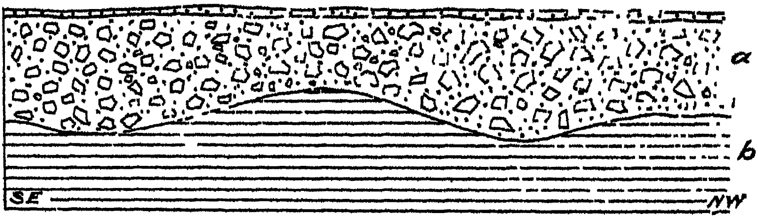

FIG. 2.—SECTION OF RAILWAY-CUTTING SOUTH OF TAIHAPE.

a. Glacial till. *b.* Marine Pliocene clays, or papa.

between Turanga-a-rere and Utiku, more particularly at 1 mile 60 chains south of Turanga-a-rere, and also at four and five miles south of that place.

The Hautapu Valley is divided from the Wangaehu River, which drains the south-east slopes of Ruapehu, by a ridge of hills that rises from 400 ft. to 900 ft. above the Karioi Flat. It is over this divide that the andesitic material has been transported by the ice radiating from Ruapehu.

There was, it would appear, a differential movement in the Ruapehu glacier, the bottom stream of ice flowing south through the Karioi Basin and thence along the Wangaehu Valley towards the sea, the upper and greater stream flowing south-east across the divide into the Hautapu Valley, carrying a load of andesitic *débris* which it spread over an area of 200 or 300 square miles. At all points the till rests on a deeply eroded surface of the marine Pliocene clays, covering hills and hollows alike along the course of the old glacial valley, the direction of which can easily be traced from any high point of view.

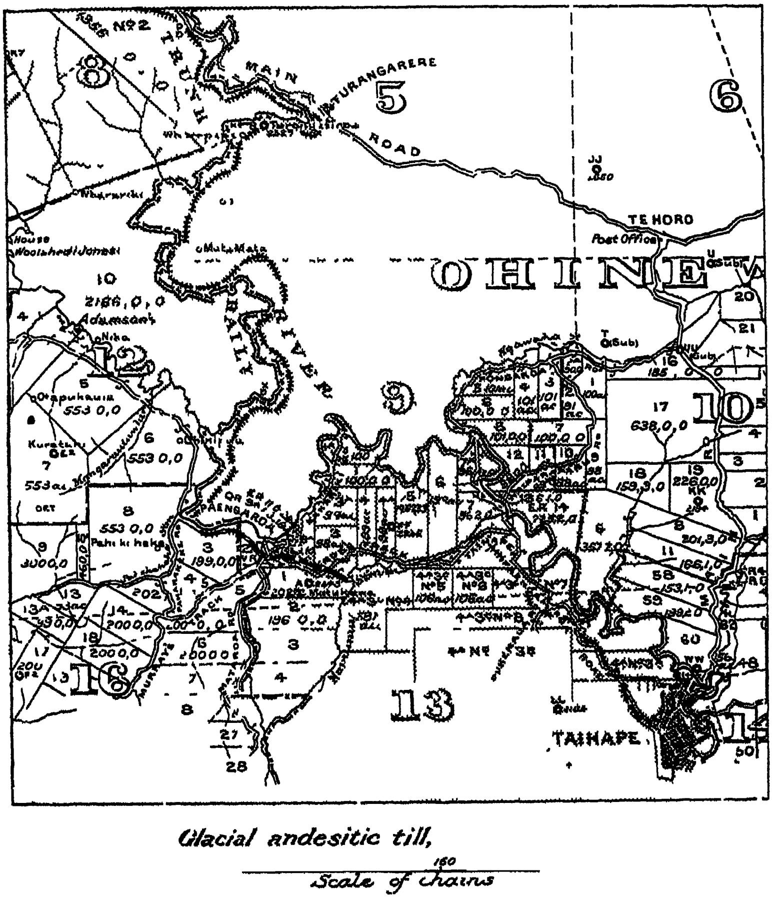

Fig. 3.—Map showing Distribution of Glacial Till in Hautapu Valley.

The Rangitikei glacier flowed southward from the Kaimanawa Mountains and Ruahine Range, and by its superior mass deflected the Hautapu glacier westward towards the Turakina. The Kaimanawas and Ruahine Ranges are composed of argillite and greywacke; hence the Rangitikei glacier, until it met the Hautapu glacier near Utiku, carried only argillite and greywacke boulders.

In the Manawatu district, the fluvio-glacial coastal drift is composed mainly of greywacke; and in the Rangitikei area, of greywacke with a sprinkling of andesitic material. Going westward, the andesitic material becomes more and more abundant, until at Wanganui it forms the bulk of the drift.

The andesitic glacial drift in the Hautapu Valley was first discovered by me during the progress of my geological reconnaissance[*] of the Main Trunk Railway route in 1886-87; but on account of the dense forest I was unable at that time to determine whether the boulders were connected with some local volcanic centre or derived from Ruapehu.

The construction of roads and railways has now enabled me to determine the true character of the deposit; while the clearing of the forest has revealed the glaciated outlines that were then hidden from view under a mantle of almost impenetrable vegetation.

Ruapehu lies in latitude 39° 15′ S.—that is, 1° 30′, or 100 miles, further north than Boulder Lake, in Collingwood, the most northerly point at which evidence of ancient glaciation is known in the South Island. The latitude of Boulder Lake is about 40° 45′ S., and of Wellington Harbour 41° 7′ S.

The manner in which glacial drifts were deposited or formed by glaciers is always difficult to explain, on account of the extremely variable character of the deposits. The most satisfactory explanations are always open to doubt. The Hautapu drift is too widespread and variable to be described as a terminal or lateral moraine, and I am inclined to think that it must be regarded as a boulder-clay or till formed mainly of interglacial *débris* deposited by the Hautapu glacier as it retreated to its centre of movement at Ruapehu. Such material would become in a measure infraglacial when the upper stream in which it was imbedded flowed over the divide into the Hautapu Valley. Besides andesite blocks, the drift in places contains angular masses of shelly limestone, sandstone, and calcareous nodules derived from the Pliocene series over which the ice crept.

The marine-clay series on the denuded surface of which the till rests has always been grouped in the Wanganui system of Pliocene age, which therefore limits the New Zealand glacial period to the Pleistocene—that is, the New Zealand ice age was synchronous with that of the Northern Hemisphere.

Ruapehu attains a height of nearly 9,200 ft. It carries permanent snowfields, and its great crater-basin is filled with what may be termed a summit glacier, or icefield. In the Pleistocene this mountain was a centre of dispersion from which glaciers radiated into the Rangitikei, Wangaehu, Upper Wanganui, and Upper Waikato, the glacier in the last flowing into the Taupo Basin, through the Rangipo Desert.

With respect to the glaciation of the North Island generally, I think it probable that further research will lead to the discovery of evidence in many other places—notably at Newtown, Karori, and Johnsonville, in the vicinity of Wellington; in the Wairarapa, near the Tararuas; and on the east side of the Ruahine Range—notably in the neighbourhood of Woodville, and east of that towards the sea.

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[*] J. Park: Reports of Geol. Expl., 1886–87, p. 69.

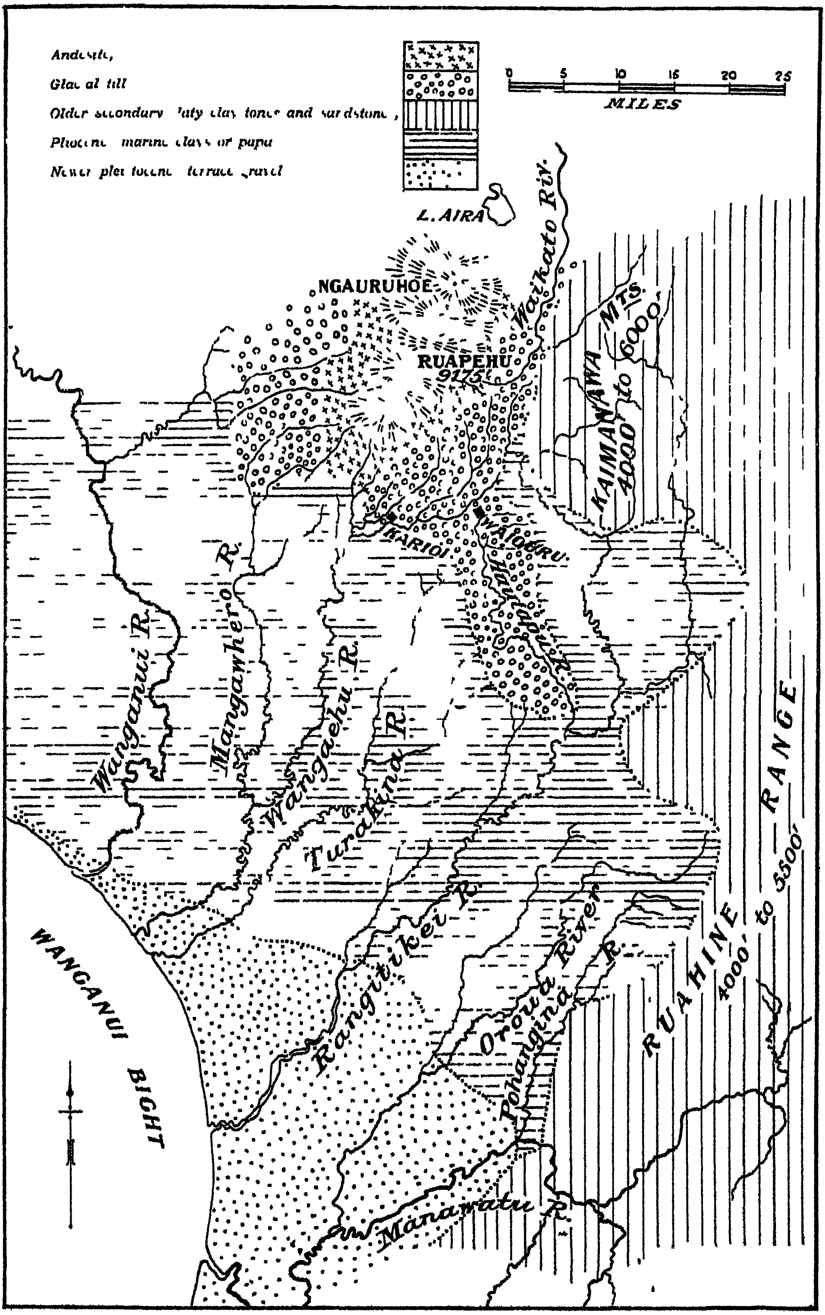

Fig. 4.—Geological Sketch-plan showing Position of Glacial Till South of Ruapehu.

NOTE.—Early in March, 1910, Mr. A. Hamilton reported the occurrence of a great andesitic-boulder deposit between the Waimarino Plain and Raurimu, on the Main Trunk Railway. Later in the same month I examined this area, and found that the western limits of the Waimarino Plain were occupied or fringed by a crescent-shaped chain of morainic hills and ridges rising from 50 ft. to 200 ft. above the level of the plain. This morainic mound stretches from the Maunganui a te ao, on the west side of Ruapehu, to the Upper Wanganui, a distance of over twenty miles. Its breadth varies from two to four miles. On the railway route it ends near Raurimu, where it is covered with a heavy drift of pumice. The Main Trunk Railway, where it crosses the Waimarino Plain, runs along the foot of the moraine for some miles. Further north the railway traverses an andesitic drift between Oio and Owhango.

North of Waimarino Station the railway passes through the morainic chain for several miles, descending to Raurimu by a series of sharp loops which are known as the "Spiral." In this portion of the line the structure of the moraine is beautifully exposed in miles of deep cuttings. The material is seen to consist of a tumbled mass of large and small angular andesite blocks mingled with reddish-brown clay and rock-rubble.

Water-worn material is absent or rare in the morainic hills traversed by the railway between Waimarino and Raurimu; and it is only when the line passes into the course of the old glacial valley of the Upper Wanganui, south of Oio, that the andesitic-boulder formation as exposed in the road and railway cuttings is found to contain a proportion of water-worn gravel and boulders.

The Waimarino moraine is a typical example of a terminal moraine. It was obviously formed by the confluent glaciers descending from the west side of Ruapehu, Ngauruhoe, and Tongariro.

ART. LIX.—*Further Notes on the Glaciation of the North Island of New Zealand.*

By Professor JAMES PARK, F.G.S.

[*Read before the Otago Institute, 7th December, 1909.*]

IN the month of November last, accompanied by Mr. A. Hamilton, Director of the Dominion Museum, I made a further examination of the great andesitic glacial drift in the lower Hautapu Valley, already described by me in a paper read before this Society in August of the present year. The primary object of our visit was to obtain photographs of the glacial deposit, and in this we were fairly successful, although the weather-conditions were not as favourable as could be wished for.

A small patch of the andesitic deposit is seen in the railway-cutting a short distance west of Waiouru, and a pile of andesite blocks lies on the coach-road to Taupo, about three miles from Waiouru; but it is only when we reach the edge of the forest-belt, near Turanga-a-rere, that the glacial deposit becomes so well developed as to attract attention. From Turanga-a-rere southward to a point half a mile or so past Taihape the andesitic material is almost continuous, being particularly conspicuous in many of the deep railway-cuttings, and along the coach-road that follows the Hautapu Valley.

A very fine section of the andesitic till is exposed near the 250-mile post, about a mile south of Turanga-a-rere Railway-station. At this place the railway-cutting passes through the glacial drift for a distance of 15 chains, exposing at one place a face 40 ft. high.

The andesite boulders are mainly angular, semiangular, or partially rounded. They range from a few inches up to over 10 ft. in diameter. And in this cutting there are also seen large angular masses of soft Tertiary sandstone mixed with the andesite blocks. The spaces between the andesite rubble are filled mostly with gritty clays, sandy material, and small pieces of andesite, mixed with a small amount of water-worn pebbles and small boulders. The general appearance of the deposit is well shown in Plates XLV, XLVI, and XLVII.

Many of the harder andesite blocks present smooth polished surfaces on one side. These surfaces are sometimes undulating or rounded, and sometimes perfectly flat. The polished surface of one boulder presented very distinct striæ.

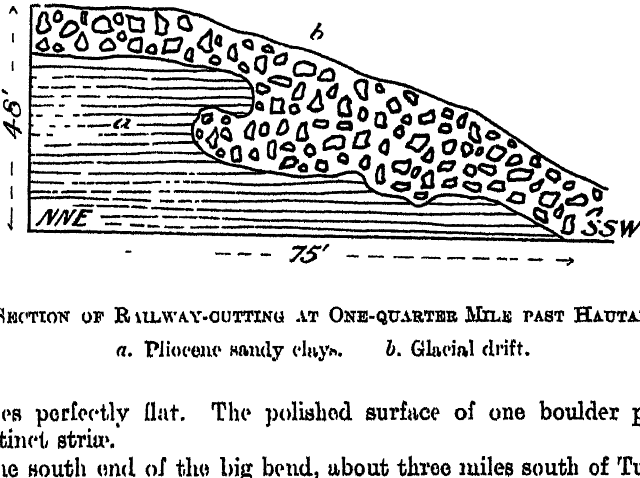

FIG. 1.—SECTION OF RAILWAY-CUTTING AT ONE-QUARTER MILE PAST HAUTAPU FALLS.
a. Pliocene sandy clays. *b.* Glacial drift.

At the south end of the big bend, about three miles south of Turanga-a-rere, at a point immediately opposite the Hautapu Falls, the andesite till crowns the hills to a height of 300 ft. above the floor of the valley. Overlooking the falls there is a nest of large andesite blocks, one of which measures 8 ft. by 6 ft. by 6 ft., and another 9 ft. by 7 ft. by 6 ft., the weight of the last being about 27 tons. These blocks are large irregular-shaped masses, with one side well polished. A group of these blocks is shown in Plate XLVIII.

It should be noted that the masses of andesite that lie on or project above the surface often show a tendency to assume a more or less rounded shape, through the process of spheroidal weathering which so commonly affects rocks of a basic or semibasic type.

The surface of the Pliocene clays on which the till rests is generally deeply eroded; and in many places it has been excavated into grotesque forms, as shown in fig. 1, where the soft clay is undercut, and in Plate XLIX, where a sharp spine-like point of clay projects into the overlying till.

At the north end of the tunnel near the 251¾-mile post there is a fine exposure of the glacial deposit in a cutting about 8 chains long. Here, as at the 250-mile post, the andesite blocks are mingled with many large angular masses of soft Tertiary sandy clay torn from the adjacent bed-rock. These masses of soft sedimentary material are quite angular, and so soft that they could not have withstood even for a few yards the pounding action of running water; hence we are forced to conclude that they now lie in the places where they were dropped by the ice.

At the 252½-mile post there is a deep cutting in which the andesite till is seen to overlie unconformably a series of stratified clays, sandy clays, and loose gritty tuff-like beds composed of andesitic material, the exposed thickness being about 50 ft. This stratified series is obviously of fluvio-glacial origin. At its base it contains a tapering lens of fluviatile drift (*b*), the greatest thickness of which is 5 ft. The whole series is intersected by a number of very distinct faults, some of which are shown in fig. 2.

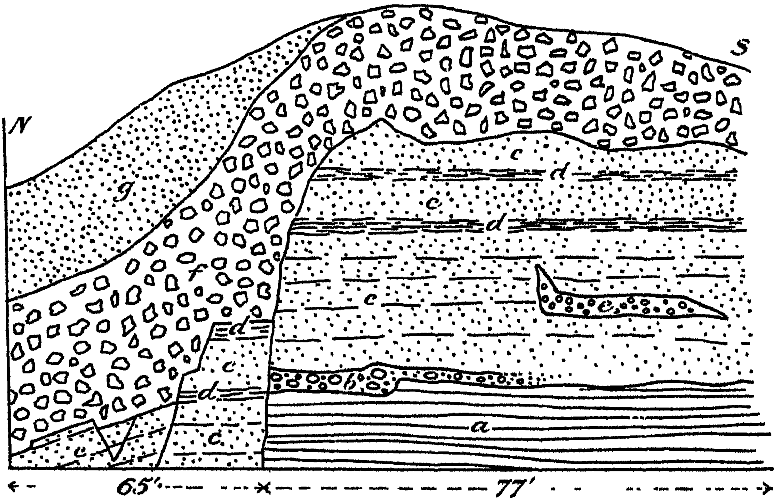

FIG. 2.—SECTION OF RAILWAY-CUTTING (SOUTH SIDE) AT 252½-MILE POST, THREE MILES AND A HALF SOUTH OF TURANGA-A-RERE. (Scale, 1 in. to 60 ft.)

a. Pliocene marine clays (papa). *b.* Andesite gravel. *c.* Sandy clays with tuff-like andesitic beds. *d.* Clayey beds. *e.* Irregular deposit of coarser andesitic grit intercalated in sandy beds. *f.* Glacial boulder rubble or till. *g.* Yellow clays.

The faulting took place before the deposition of the upper andesite rubble drift or till, as shown by the circumstance that the till rests unconformably against the faulted ends of the stratified beds. Moreover, the faults do not affect the till in any way.

This evidence is of great importance, as it clearly points to the existence of two phases of glaciation in the North Island during the Pleistocene. This section is shown in fig. 2 above and in Plate L.

The glacial till is well exposed in the railway-cuttings between the tunnel at 252½ miles and Ngaurukehu Siding, and between Mataroa and Taihape.

South of Mataroa the glacial till rises on to the summit of the ridges bounding the Hautapu Valley, at many places lying at an elevation of over 2,000 ft. above the sea, or from 800 ft. to 1,000 ft. above the floor of the valley.

Near Mr. W. Showan's house, about two miles south of Mataroa, there is a perched block of andesite measuring 11 ft. by 6·5 ft. by 6 ft., and weighing over 30 tons.

At Mataroa quarry the andesitic till is seen resting on a fluvio-glacial drift that occupies a gulch in the young Tertiaries. This gulch is obviously the gutter or channel in which the subglacial river ran. In Scotland the boulder-clay is frequently found resting on fluviatile drifts lying in ancient valleys.

The Mataroa drift is mainly andesitic, but there are also present many partially rolled blocks of the harder calcareous sandstone that occurs in nodular form in the blue clays. These blocks are very numerous at the base of the drift; but they also occur scattered throughout the whole mass, which is rudely stratified, and in places shows current bedding.

The andesitic till is strongly developed around Taihape, more especially on the west side of the Hautapu Valley. Plate LI shows the drift lying on the hillside near Taihape Railway-station.

A mile below Taihape, and at many places on both sides of the gulch in which the Hautapu River flows, there are many fine exposures of the re-sorted andesitic gravels formed by the Hautapu River when it ran at the higher flood-level. These gravels can be traced southward almost continuously to the junction of the Rangitikei River. Here and there they form high-level terraces along the course of the river, their upper surface marking the ancient flood-level of the river. They do not rise above the 1,150 ft. contour, and descend by a gentle gradient to the junction of the Rangitikei River. The material is mainly andesitic, and there is no difficulty in distinguishing it from the glacial till, which consists of large masses of andesite set in a clayey and sandy matrix, and forms a sheet on the spurs and ridges above the 1,450 ft. contour.

I have elsewhere described the Hautapu andesitic deposit as a boulder-clay or till of glacial origin, and my more extensive examination in November last, in the company of Mr. Hamilton, has more than confirmed my earlier conclusion.

For the first twenty-five miles nearest Ruapehu the deposit consists almost entirely of clays or sandy material containing blocks of andesite sparsely throughout it. About a mile and a quarter north of Turanga-a-rere andesite boulders are numerous and small in size; but going down the Hautapu—that it is, further from Ruapehu, the source of the andesite—the blocks become more and more abundant, and also of greater size, until we reach the ridges between Mataroa and Taihape, where we find masses ranging up to 30 tons in weight perched at a height exceeding 2,100 ft. above the sea, at a point over thirty miles from their source at Ruapehu. On Mataroa Hill the blocks lie at about the same height as that of the divide between the Wangaehu and Hautapu watersheds.

There is no agency but glacier-ice known to science competent to tear huge masses from their parent rock, transport them over a divide into another watershed, and scatter them in a sheet over an area of several hundred square miles in extent, at their extreme limit over forty miles from their source. And, as previously noted, the greatest development

I made a careful examination of this coastal shelf in 1887 and again in 1888, and on these occasions satisfied myself that it was not an uplifted marine platform of erosion.

Maritime platforms are distinguished by their uniform height and a uniform shelving gradient towards the sea. The Terawhiti shelf varies greatly in height, and its surface is undulating.

At the time of my earlier examinations I was unable to find a satisfactory solution of the origin of this coastal terrace; but I now think that an ice sheet or glacier flowing through the depression occupied by Cook Strait would be able to excavate the fringing platform we now see.

The Terawhiti shelf has a singular resemblance to the Crown Terrace, a glacier platform that fringes the north side of the Arrow Basin, in the Wakatipu region.

After passing Cape Terawhiti, Mana Island is seen lying at the entrance to Porirua Harbour. This island is flat-topped, its shape being almost identical with that of the flat ice-shorn islands in Lake Wakatipu.

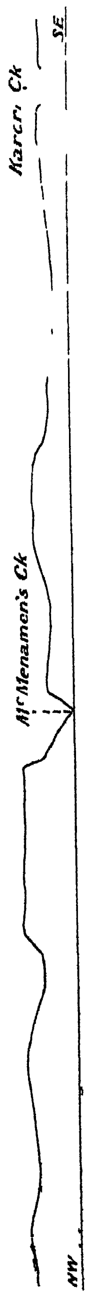

FIG. 3.—ROCK SHELF FRINGING COAST NEAR CAPE TERAWHITI.

FIG. 4.—SHOWING MANA ISLAND, AS SEEN FROM COOK STRAIT.

Passing over to Queen Charlotte Sound, we find that the long, narrow, descending spurs that separate the numerous arms or inlets that open out of the main sound are worn down into long, tapering wedges, the crest of which, at their lower end, is frequently truncated and terraced.

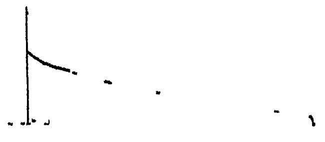

FIG. 5.—SHOWING WEDGE-SHAPED SPUR SEPARATING ARMS OF THE SEA IN QUEEN CHARLOTTE SOUND.

These wedge-shaped spurs are quite a conspicuous feature in the land forms. They have a curious resemblance to the tapering spur lying between the two arms of Moko Lake, in the Wakatipu district.

Proceeding through the sounds towards Cape Jackson, we pass Jackson's Hump, which, whether viewed from the east or the west side, is seen to be a perfect dome. This well-known landmark is situated on the narrow peninsula on he extreme end of which lies Cape Jackson.

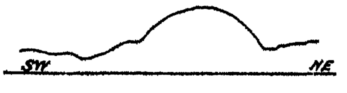

FIG. 6.—SHOWING JACKSON'S HUMP, VIEWED FROM THE EAST SIDE.

Many of the spurs that project into the sounds are sharply truncated in the manner shown in fig. 7, below.

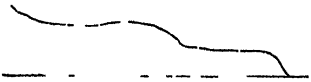

FIG. 7.—SHOWING PROFILE OF TRUNCATED SPUR IN QUEEN CHARLOTTE SOUND.

Besides being truncated on the crest, the ends of the spurs are sometimes terraced with a succession of rock shelves. A good example of this is seen at the north-east end of Chatwood Island, which is passed before reaching the French Pass.

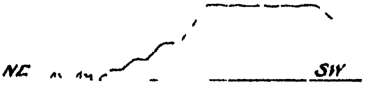

FIG. 8.—SHOWING TERRACED END OF CHATWOOD ISLAND

Between the French Pass and Nelson there is the Lion Island, which presents the characteristic appearance of an ice-worn surface.

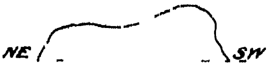

FIG. 9.—SHOWING LION ISLAND, BETWEEN CABLE BAY AND FRENCH PASS.

To the south-east of Nelson we have Saddle Hill, with its twin domes, Sugar Cone, and other hills nearer the town, the smooth outlines of which are strongly suggestive of ice erosion.

At the Port Hills, Nelson, there is a thick deposit of gravel, sand, and clay, rudely stratified. This deposit rests on a highly denuded surface of the Miocene Tertiaries, forming the front of the Port Hills, and is faulted and tilted at various angles. It is mainly composed of greywacke and granite, both derived from the neighbourhood of Mackie's Bluff. It is quite clear that this drift at one time extended continuously from Nelson across the mud-flat to Wakapuaka. Its removal from this area is the work of the Maitai River.

The Nelson Boulder-bank is mainly composed of greywacke and granite boulders which have been derived from the great Wakapuaka drift, a portion of which, as we have seen, still remains at the Port Hills. In other words, the Boulder-bank is composed of the re-sorted material of the great drift being piled up in its present form by the action of the sea-currents on the one side and by the Maitai and other streams that enter the bay on the other side. That this drift came from the north-east is proved by the character of the material. The material is fluviatile; but the existing rivers run transversely to the course of the river that must have transported it to its present place. This ancient river must have flowed from the direction of the French Pass. The question is, Was this ancient river connected with the Cook Strait glacier?

The Moutere gravels are composed of greywacke, and can be traced continuously from the shores of Golden Bay to the Hope Saddle. They are obviously a fluvio-glacial drift, carried forward by the river that drained Rotoiti glacier.

A great fluvio-glacial drift covers the terrace land and mountain-slopes in the Aorere district, Collingwood. This drift can be traced from sea-level on to the crest of the ridges fronting Golden Bay, being found as a thin covering up to a height of 3,000 ft. above the sea. The fluvio-glacial origin of this drift was first recognised by Dr. Bell during his survey of the Parapara district in 1907.

The *roches moutonnées*, rock-basins, and moraines at Boulder Lake, Collingwood, have already been described by Dobson, Bell, and myself, and require no further reference here.

The crest of the Whakamarama Range, near Collingwood, has been ice-shorn into many beautiful *roches moutonnées* and domes, and in the drift at the foot of the range there are many striated and polished boulders of greywacke. Granite boulders are plentiful, but none of them show ice-striæ.

The evidence showing that glaciers descended to what is now sea-level in the vicinity of Cook Strait is very strong, and when taken in conjunction with the glaciation of the Rangitikei Valley would seem to prove that the greater portion of the South Island and a large portion of the North Island was glaciated in the Pleistocene. A single bit of evidence might be open to doubt, but when all the evidences are strung together they become culminative. The evidence obtainable in Otago, Southland, Canterbury, Nelson, and Wellington would seem to afford conclusive proof that the Pleistocene glaciation attained a greater magnitude than hitherto supposed.

NOTE.—Since the above was written I have found that great piles of morainic *débris* occur near Cape Campbell, at the mouth of Kekerangu River, and near the mouth of Shades Creek, all in Marlborough. The material consists mainly of silts, clays, sands, gravels, and boulders, mingled with huge angular masses of Saurian sandstone, Amuri limestone, and enormous masses of fossiliferous sandstone and clay rock derived from the Awatere formation. These moraines are fully described elsewhere. It may, however, be interesting to note here that the masses of fossiliferous clays, sandstones, and silts belonging to the Awatere formation are altogether foreign to the Kekerangu and Shades Creek areas. Where the parent rock was situated is not known.

ART. LXI. *The Great Ice Age of New Zealand.*

By Professor JAMES PARK, F.G.S.

[*Read before the Otago Institute, 22nd September,* 1909.]

NEW ZEALAND geologists and physiographers have always agreed that there was a period of intense refrigeration in the South Island in very late Tertiary times, and all have agreed that this refrigeration was caused by an elevation of the land. There has, however, been some disagreement as to the extent and date of the glaciation caused by this refrigeration.

With respect to the extent of the glaciation, Mr. J. T. Thomson and Sir Julius von Haast maintained that the whole of the South Island was covered with a continuous ice-sheet; while Sir James Hector, Captain F. W. Hutton, Mr. A. McKay, and Mr. W. T. L. Travers held the view that the main Alpine divide was occupied by an immense icefield from which gigantic glaciers descended to the sea on the west coast, and on the east coast reached the Canterbury and Southland plains. The glacier which occupied the Taieri Basin from near Dunedin to the south of Milton was admitted by Hutton to have crept over the coastal hills to the present coast-line. In the late "seventies" Haast modified his first view as to the extent of the glaciation. Up till the year 1907, but without having made any special review of the evidence, I gave a general support to the contention of Hector and Hutton.

The Glacial period of New Zealand was believed by Hector, Haast, and McKay to have taken place in the Pleistocene—that is, contemporaneously with the Ice Age of the Northern Hemisphere. Hutton, on the other hand, placed it at a somewhat earlier date—that is, in the Pliocene; but in my review* of the "Marine Tertiaries" of Otago and Canterbury I showed that the Greta and Awatere beds of the South Island were older Pliocene, and not Miocene, thus removing Hutton's difficulty as to the Post-pliocene glaciation.

During the progress of my geological survey of the Wakatipu region† in the summer of 1907 8, among new evidences of glaciation I discovered that the mountains on the north-east side of the lake were covered with a stony boulder drift up to the height of 4,000 ft., mainly composed of erratics transported from the Livingstone Mountains, and that the mountains were ice-shorn and cut into shelves up to a height of 6,500 ft. above the sea. As a result of my observations, which are fully recorded in my bulletin on the Wakatipu district, I estimated that during the glacial period the ice formed a continuous sheet that stretched over the greater part of the South Island, in the Wakatipu Basin attaining a thickness of over 7,400 ft. In support of my contention that the ice-sheet reached the sea on the east coast, I referred to the glacial boulder-clays near Dunedin, the glacial drift overlying the coastal hills between the Taieri Plain and the sea, and the loess at Oamaru and Timaru.

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* J. Park, Trans. N.Z. Inst., vol. xxxviii, 1904, pp. 536 and 547.

† J. Park, "Geology of Wakatipu Area," Bulletin No. 7 (New Series), N.Z. Geological Survey, 1909.

I ascribed the cause of the glacial period to an elevation of the land, which I estimated at not less than 3,000 ft. Reviewing all the evidence, I expressed the opinion that during the period of maximum elevation it was not improbable that the polar ice-sheet reached as far north as New Zealand.

In my presidential address* to the Otago Institute in May, 1909, I reviewed the evidence submitted in my official report, and reaffirmed my belief that the glacial period of New Zealand was Pleistocene, and in all respects parallel with that of the Northern Hemisphere. And, arguing from the evidences of glaciation in the Auckland, Campbell, and other islands lying south of New Zealand, in Tasmania, and in South America, I hazarded the opinion that all the land-areas in the Southern Hemisphere up to corresponding latitudes were glaciated at the same time as New Zealand. I further suggested that during this great southern Ice Age there was probably an invasion of the Antarctic ice-sheet, in the same way as in the Glacial epoch of the Northern Hemisphere there was an advance of the Arctic ice-sheet.

A close scrutiny of the topographical features of those portions of Southland, Otago, and Canterbury lying on the east side of the axial divide discloses evidence on all hands that the present configuration of the surface has been moulded by ice erosion.

The slopes and summits of the Hector and Eyre Mountains, overlooking the South Arm of Lake Wakatipu, are ice-shorn up to a height of 5,500 ft., the smooth, flowing outlines of the former in particular standing up in conspicuous and striking contrast to the sharply serrated and rugged summits of the adjoining Remarkables, that stood above the surface of the Pleistocene ice-plateau.

The Wakatipu region was the centre of movement of the ice-sheet which flowed southward across Southland and eastward across Otago, the track of the ice being plainly marked in a thousand places.

The smooth, flowing contours, dome-shaped summits, truncated spurs and ridges, and U-shaped valleys that are so well developed in the Wakatipu district can be traced from the Hector Mountains, opposite Kingston, across the Hokonui Hills to the Southland Plain, from which rise the Bluff Hills, themselves merely gigantic ice-shorn *roches moutonnées*. From the Upper Nevis, Nokomai, and Mataura the same smooth, rounded outlines can be followed eastward to Gore, and thence northward to Otago Peninsula, without a break except where recent fluviatile erosion has modified the glaciated surfaces. For example, near Athol the Mataura River and its branches have eroded deep V-shaped channels in the older glaciated slopes; and so sudden is the change from the smooth, rounded contours to the characteristic tent-shaped ridges and V-shaped valleys that the contrast but serves to emphasize the startling difference that exists in land-forms modified by ice and by running water—a difference so fundamental and conspicuous that it needs not the trained eye of the topographer to discern it.

Sir Archibald Geikie, in his charming book on the "Scenery of Scotland," when discussing the origin of the smooth, rounded outlines of the Scottish mountains, asks the question, "What agency other than ice is capable of producing these forms?" The ice-worn outlines have been traced down to the present coast-line between Southland and Dunedin.

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* James Park, "The Physiography and Glaciation of Otago," *Otago Daily Times*, 12th May, 1909.

And it may be as well at this point to inquire what other evidence we have that the ice-sheet reached thus far eastward.

At Munro's Gully, Blue Spur, and Weatherstone's, in the lower Clutha, there is a thick deposit of fluvio-glacial drift resting on a mica-schist floor. The drift is mainly composed of rounded boulders of greywacke and angular masses of mica-schist. The greywackes are erratic, and must have been transported from a distance. The mica-schist is local. Hutton thought that the parent source of the greywacke was the Tapanui Range, lying some twenty miles to the westward; and in this surmise I think he was probably right.

The well-known Taieri Moraine forms the front of the coastal range lying between the Taieri Plain and the sea, extending from Mount Misery, south of Milton, to Allanton, a distance of twenty-five miles. It attains its greatest development between Waihola and Otokaia, where it forms hills varying from 250 ft. to 700 ft. high.

It is easily divisible into two unequal parts—namely, an upper and a lower series. The upper division is mainly composed of coarse angular fragments and blocks of semi-metamorphic mica-schist, mingled with gritty silt and a certain proportion of semi-rounded schistose gravel. The whole mass is partially consolidated into a breccia-conglomerate. The pervading colour is light red.

The thickness of this division is some 450 ft. In the upper portion of it there occur many masses of schist ranging from 6 ft. to 12 ft. in diameter. These are perhaps more abundant behind Waihola and Henley than elsewhere.

The whole of the material shows a certain rude stratification that can be easily distinguished along the bank of the Taieri River and in the high slips near the crown of the hills behind Henley Inn.

The lower division comprises the main portion of this glacial drift. It is beautifully exposed in the road-cuttings that follow the north bank of the Taieri River from the bridge at Henley to the upper end of the gorge. It consists of a great succession of red clays, gritty and sandy clays, and beds of well-waterworn gravel that commonly contain a large proportion of small angular fragments of mica-schist. In a few places there are beds of angular masses of rubbly schist in which many blocks are over a foot in diameter.

The whole of the material is well stratified, and diagonal bedding is not uncommon. The dip is towards the north-north-west for a distance of two miles, at angles varying from 10° to 33°. The mean angle is not less than 16°, giving an apparent thickness of over 3,000 ft. At Cotter's Gully, and also opposite Crab Island, there is a distinct steeping of the inclination of the beds, which, taken in conjunction with the long lines of escarpment on the south side of the river, may be taken to indicate faulting. If the suggested faulting has taken place to such an extent as to cause the repetition of the beds, I estimate that the thickness must in any case exceed 1,000 ft. But I wish to make it clear that it was the extraordinary apparent thickness of the beds that first suggested repetition rather than any physical appearance of faulting, of which there is no satisfactory evidence. I wish further to say that Sir James Hector,* in his diagrammatic representation of this section, shows a continuous dip from the upper end of the gorge to the summit of the coarser upper member of the series facing the Taieri Plain.

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* J. Hector, Rep. Geol. Exp., 1890–91, p. lx.

Hector* and McKay† found the Taieri glacial beds so well stratified that they placed them in the brown coal series of Lower Tertiary age. The better opportunity for examination now given along the new road following the north bank of the Taieri, described above, shows that there is no evidence to justify this correlation.

South of Waihola and north of Allanton the glacial material dwindles down to a thin sheet that towards its outer limits in the south is represented by only a few scattered blocks of basalt. Passing eastward towards the sea, the eastern limit of the syncline rests against a highly denuded surface of the mica-schist. To what distance the glacial drift formerly reached in this direction it is impossible to say. All that now remains of it is a thin sheet of gravel and clay that appears here and there on the hill-tops fronting the sea.

[NOTE.—Hutton, Hector, and McKay have recorded the Taieri Moraine on the hills overlooking the Tokomariro Plain. Last July, Mr. A. Gordon Macdonald, B.E., and I traced it to the north bank of the Tokomariro River; and since then Mr. Macdonald has pointed out that the front of Mount Misery up to a height of 1,000 ft. above the sea is covered with a thick deposit of glacial moraine drift. I have lately verified this further extension of the Taieri Moraine.]

Briefly stated, we have in the Taieri Moraine a glacial deposit varying from 0 to 1,500 ft. or more in thickness. The upper layers, 450 ft. or 460 ft. thick, are composed of coarse, angular, and gravelly drift rudely stratified; the lower and major portion, over 1,000 ft. thick, consists of well-stratified silts, sands, and gravelly drift. The deposit can be traced over a distance of nearly twenty-two miles in length, and over a width varying from one to three miles.

The Taieri glacial deposit is, according to Dr. Marshall, the terminal moraine of a glacier that flowed across Central Otago, entering the Taieri Basin from the west. The beautifully glaciated slopes of the mica-schist uplands lying immediately west of the Taieri Plain, and the domed summit of Maungatua, bear eloquent witness of the path of this ancient ice-sheet; but I cannot agree that the moraine is terminal. At any rate, it bears no resemblance to such typical ancient terminal moraines as those at Clyde, Lower Kawarau Gorge near Cromwell, Kingston, Von, Waitaki, Lakes Guyon, Tennyson, Rotoroa, Rotoiti, and Brunner. Nor can I find in the literature of glaciation a reference to any terminal moraine consisting of such an assemblage of stratified deposits.

The terminal moraines of ice-sheets consist of tumbled masses of rock dumped over the face of the ice, and seldom show the sorting of fluviatile action. The terminal moraines of valley-glaciers, on the other hand, often show rude sorting of the coarser matter, effected by the river issuing from the bottom of the glacier, the muds and finer material being generally carried away in the flowing stream. But from first to last the tumbled, angular, unsorted material predominates.

In the Taieri Moraine the finer material forms 80 or 90 per cent. of the whole deposit. It is well stratified, and the stratification can be traced over a length of twenty miles. Subglacial and fluvio-glacial agencies alone seem competent to account for the formation of this pile of bedded glacial drift.

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* J. Hector, Rep. Geol. Exp., 1890–91, p. lx.

† A. McKay, *l.c.*, p. 45.

GLACIATION OF THE NORTH ISLAND.—Park.

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GLACIATION OF THE NORTH ISLAND.—Park.

I have described the Taieri glacial deposit as a ground-moraine, as opposed to the view that it is a terminal moraine. Dr. Marshall* challenges this conclusion, asserting that a boulder-clay or ground-moraine is relatively thin because formed between the ice and the bed-rock, whereas the Taieri Moraine is, he says, at least 700 ft. thick. In making this statement he would seem to have fallen into an error. The thickness of boulder-clays, as recorded by eminent geologists, proves conclusively that such deposits are not relatively thin, but, on the contrary, relatively thick.

The till of Scotland, according to Sir Archibald Geikie, varies from 0 to 160 ft. thick; and that of North America,† according to Professor Salisbury, from 0 to 500 ft. At Back Valley, in South Australia,‡ the Committee on Glaciation of the Australasian Association for the Advancement of Science reports a Permo-Carboniferous glacial drift or till 1,500 ft. thick. In Germany§ the Pleistocene glacial drift varies from 0 to 670 ft. thick.

In Greenland,‖ Geikie tells us, "Nansen found enormous accumulations of ground-moraine on the edge of the inland ice at Austmannatjern, where there were no nunataks, and not a vestige of surface moraine was visible."

The Cambrian glacial beds of South Australia are described by Mr. W. Howchin ¶ as being 1,500 ft. thick in the gorge of Appila, including, to use his own words, "860 ft. of characteristic till with boulders." Thus we find that from the earliest geological times up to the Pleistocene a glacial till is not relatively thin, but may be many hundred feet thick.

Professor Marshall also states that a boulder-clay is more or less continuous in its disposition over the whole area covered by the ice-sheet. This statement also is at variance with known facts. In Scotland, which was completely covered with the northern ice-sheet in the Glacial period, the till is not only notoriously irregular, but it covers a relatively small portion of the country. In writing of the unequal distribution of the glacial drift, or till, in North America,** Professors Chamberlin and Salisbury state that "The thickness of the drift ranges from zero to 500 ft., and the variations are often great within short distances. One hill may be composed of drift, while the next has no more than an interrupted mantle of drift. The drift may be thick on hills and thin in valleys, but more commonly the reverse is the case." Irregularity is, without doubt, one of the distinctive features of a glacial till.

The Taieri Moraine reaches its northern limit south of Saddle Hill, but small areas of glacial till occur, as first pointed out by Mr. J. T. Thomson,†† in the Kaikorai Valley, more particularly at Fernhill Coal-mine, Abbotsford, and Burnside. The till consists for the most part of confused deposits of angular and semi-angular boulders of igneous rocks and clays, generally unstratified; but in some places the material is irregularly bedded, as may be seen in the steep escarpment overlooking Fernhill Coal-mine.

The moraine at Abbotsford is a typical example of a glacial till. It begins at Abbott's Saddle, overlooking the Taieri Plain, and extends from the railway-line northward for half a mile or more, occupying the lower portion of the Kaikorai Basin. It was known to and figured by Hutton* as far back as 1876. Its south-east slope is knobby and hummocky, the hummocks in many cases enclosing undrained hollows between them, while its upper surface presents smooth, flowing contours. The material consists of peaty clays containing moa-bones, generally much decomposed, stiff yellowish-brown clays containing an irregular bed of bouldery gravel, followed by clays and a confused mass of boulders.

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* P. Marshall, *Otago Daily Times*, 13th May, 1909.

† Chamberlin and Salisbury, "Geology," vol. iii, p. 346.

‡ Proc. A.A.A.S., vol. vii, p. 126; 1898.

§ A. Geikie, "Earth Sculpture," 1902, p. 191.

‖ A. Geikie, *l.c.*, p. 176.

¶ Walter Howchin, Trans. A.A.A.S., vol. xi, p. 266.

** Chamberlin and Salisbury, "Geology," vol. iii, p. 346.

†† J. T. Thomson, Trans. N.Z. Inst., vol. vi, p. 313.

At present, however, I am not so much concerned with the particular manner in which the Taieri and Kaikorai glacial deposits were laid down or formed as with what the deposits stand for. They mean that a gigantic glacier or ice-sheet descended from the distant main divide in western Otago to the present coast-line, occupying the Taieri and Tokomairiro basins from Dunedin to the Clutha, and presenting a continuous ice-face over forty miles long. The *débris* it has left in its track proves that it rode over the coastal range on its way to the sea. This ice-sheet crept across the uplands of Central Otago, which present no dominating or leading valley leading to the Taieri Basin.

The present cañon of the Taieri River, in Central Otago, and gorges of the Waipori and Clutha, as well as the lower gorges of the Tokomairiro and Taieri, that cut through the coastal range, are admittedly features of comparatively recent date, excavated since the recession of the ice.

The glacial deposits in the Waikouaiti Valley, in the lower valleys of the Waitati and Canterbury rivers, at the south end of Lakes Rotoroa and Rotoiti, and at Boulder Lake, all attest the eastward advance of the land-ice, and the widespread magnitude of the glaciation. Such intense refrigeration as this implies could not but affect the North Island; and of this we have ample evidence provided by the great glacial till in the Hautapu Valley, on the Wellington–Auckland Main Trunk line.

In the vicinity of Dunedin we find that Saddle Hill, Maungatua, and the uplands facing the Taieri Basin, Flagstaff, Swampy Hill, and the hills on each side of Otago Harbour, everywhere present smooth, flowing contours, in many places impressed with fluviatile features of later date. Flowing contours, domed hills, and truncated spurs are the work of no known agency but ice. It is admitted that an ancient glacier or ice-sheet of enormous size occupied the Taieri Basin. How, then, can we, if we view the position without prejudice or bias, deny that ice was the active agency in forming these flowing features when we know that a gigantic glacier existed so near at hand? Whatever the cause of the Ice Age, we cannot escape the conclusion that when the Taieri glacier extended to the sea, the climatic conditions on the east coast of Otago must have been antarctic; and all polar discovery has shown that under such intense refrigeration every valley would be filled with glacier-ice, and the whole region a waste of ice and snow.

In my Bulletin† on the Wakatipu region I referred to the Kaikorai boulder-clays as glacial, and not, as assumed by Dr. Marshall, to the clays that lie along the summit of the ridge on which Maori Hill, Roslyn, and Mornington stand. These clays are obviously residual, and as such have always been described by me.

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* F. W. Hutton, "Geology of Otago," 1875, pl. vii.

† J. Park, Bulletin No. 7, N.Z. Geol. Surv., p. 43; 1909.

The Rev. James Christie* has stated that Saddle Hill owes its distinctive form to ice erosion; and after a careful examination of its topography I am entirely at one with him. The seaward slopes of Saddle Hill exhibit beautiful, smooth, undulating contours, and I am satisfied that the two main knobs of the hill, as well as the small knob lying to the east of these, are *roches moutonnées* in a good state of preservation.

Waihola Lake, and the Taieri Basin, of which it is a part, are good examples of U-shaped valleys, as also is the Kaikorai Valley, which heads into a fine glacial cirque at the source of the Leith Stream. The Tokomairiro is also a glacial basin. It is a continuation of the Taieri Basin, and is separated from the Clutha glacial valley by some low ice-shorn hummocky hills.

At Wingatui, following the foot of the mica-schist hills, there is a deposit of brick-clay some 50 ft. thick, consisting of thin horizontal alternating layers of rock-flour and gritty clay. The material is not residual, but aqueous, and is almost identical with the fine bedded glacial clays at Lake Hayes and Kawarau Falls, near Lake Wakatipu. The existence of the glacial moraines at Allanton, a few miles to the south, and at Ferntown, a few miles to the north, and the existence of an ancient glacier in the Taieri Basin, are strongly suggestive of the glacial origin of these clays.

The slopes and crests of Flagstaff, Swampy Hill, Pine Hill, and of Otago Peninsula, when viewed from almost any standpoint, exhibit smooth, sweeping contours, domed crests, and truncated spurs, in many places dissected by the later streams draining the slopes. Moreover, the higher slopes of Swampy Hill, facing the Upper Leith; the slopes of the Otago Peninsula behind Anderson's Bay; and the higher slopes of Sidey's Hill, opposite Abbotsford, are excavated into tiers of more or less parallel shelves- a feature that I have shown is often associated with ice erosion in the Wakatipu region.

No one has ever claimed that the Otago Harbour is a submerged valley of fluviatile erosion. Such a hypothesis would at once be faced with insuperable difficulties, not the least being a satisfactory explanation of the sudden cessation, or ending, of the valley at Dunedin without leaving a trace of its former existence to the westward of the city. It seems not improbable that the site of North Dunedin, embayed as it is on three sides with encircling hills, was a glacial basin from which one stream of ice passed seaward through the gap between Lawyer's Head and St. Clair, while another stream flowed down Otago Harbour.

As a matter of fact Otago Harbour consists of two distinct basins—namely, the Dunedin Basin and the Port Chalmers Basin—which are separated by a chain of islands that extend from side to side with only narrow, shallow channels between them.

The Leith is obviously a young stream that has eroded its present narrow rift-like gorge down to the floor of the Dunedin cirque since the glacial period.

Mr. Christie has expressed the opinion that Otago Harbour was the work of ice erosion. I am so far in agreement with him in believing that the harbour was occupied by a glacier which deepened it and moulded the adjacent hills, imparting to them the flowing contours and beautiful catenary curves that are so conspicuous on each side.

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* J. Christie, *Otago Daily Times*, May, 1909.

The glacier that occupied the North-east Valley formed the fine amphitheatre-like cirque between Mount Cargill and Signal Hill, and, flowing southward, joined the Dunedin glacier, truncating Logan's Point spur into a broad platform as it turned around the lower slopes of Signal Hill.

Dr. Marshall supplemented his remarks with respect to the supposed inability of ice-thrust to bend or break the least resistant schist with some observations apparently meant to convey the meaning that the ancient ice in the Wakatipu region was incompetent to cause the bending of the schists. In my Bulletin on that area, speaking of the outcrop-bending the weak mica-schist of the Arrow and Shotover has suffered, I stated (p. 43), "The bending of the rocks is the work of the ice-sheet that covered the mountains in the glacial period. It often obscures the true dip." Further on I mentioned that on account of this bending it was impossible to get trustworthy observations for dip and strike over considerable areas.

Referring to the ability of ice to crumple and disrupt rocks, Geikie* says, "While the general surface of the land has been abraded by the ice-sheets, more yielding portions of the rocks have been broken off, bent back, or corrugated by the pressure of the advancing ice." Further on he continues, "The laminæ of shales or slates are observed to be pushed over or crumpled in the direction of ice-movement." And, again,† speaking of the bending of fissile strata, he says, "Similar effects, with even proofs of contortion, may be observed under boulder-clay, or in other situations where the rocks have been bent over and crushed by a mass of ice."

In many places the freshness of the glaciated slopes and hummocky moraines is as conspicuous on the coast-line as it is at Wakatipu, which is the more remarkable when we observe that contiguous areas of hard rock have been deeply dissected by streams. This differential erosion is a common feature of glaciated regions, and has been a subject of much discussion and speculation in Europe and America. Mr. G. W. Lamplugh, F.R.S.,‡ of the British Geological Survey, in a recent paper on the "Surface Features of Glaciated Areas," when dealing with this matter, makes the following interesting statement: "In the detailed examination of districts overspread by glacial deposits, I have been constantly impressed by the great discrepancy between the effects of erosion on contiguous tracts. On the one hand, drumlins of boulder-clay, esker ridges and kame-mounds of sand and gravel, and moraines of incoherent rubble, though all composed of material yielding readily to erosion, have retained with very slight impairment their original shape and position in spite of the steepness of their slopes, so that one might imagine that the forces of denudation had been almost in abeyance in the district since the close of the glacial times. On the other hand, a neighbouring stream-channel will often show in the clearest manner that during the same period the erosive agencies have been particularly energetic, so that the stream may not only have cut its trench through a thickness of drift, but may also have notched deeply into the underlying solid rock. My attention was particularly directed to these divergent conditions in Ireland, where they are everywhere prevalent. But I have since recognised in varying degree the same anomalies in every glaciated region that I have studied."

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* A. Geikie, "Geology," vol. ii, p. 1300.

† A. Geikie, *l.c.*, vol. i, p. 669.

‡ G. W. Lamplugh, *Geographical Journal*, July, 1909, pp. 55–56

Lamplugh thinks that the preservation of the glacial forms was due to the protection afforded by permanent snowfields. He argues that during and for some time after the recession of the ice the refrigeration would still be sufficiently intense to cause the formation of fields of permanent or nearly permanent snow that would protect the ground on which it lay from subaerial waste or denudation, fluviatile action being confined to the defined watercourses. The contention seems not unreasonable.

When considering the genesis of the present topography of the Otago Peninsula and neighbourhood we must not forget the influence the rock formations would be likely to exercise in the development of characteristic surface-forms. The rocks consist of a pile of basic and semi-basic lavas—emissive and hypabyssal alternating with beds of tuff and breccia.

These rocks rise to a height of 2,000 ft. or 3,000 ft., and from their character and origin one would naturally expect them to form broken ridges, diversified with frowning precipice and steep escarpment, as do the piles of andesitic rocks in the Hauraki Peninsula. Instead of these, we have everywhere the smooth outline and flowing contour commonly presented by intensely glaciated surfaces, diversified by stream-dissected features.

From Dunedin to Timaru the dominant feature of the topography is the smooth, flowing contours, dome-shaped hills, and truncated crests; while everywhere the valleys are U-shaped. The amount of recent stream erosion is surprisingly insignificant, and where it had taken place is easily distinguishable from the glaciated surfaces.

Glacial till is well developed between Puketeraki and Merton, and there, as near Seacliff, it forms conspicuous hummocks and hollows. The moraine at the former is doubtless a continuation of that spoken of by Mr. Christie* as occurring at Cherry Farm.

The land-forms in the lower end of Waikouaiti Valley, and of the encircling hills and ranges, everywhere bear unmistakable evidence of glacial erosion. On the north side of the valley stand the basalt-covered hills, Hawkswood, Bald Hill, and Mount Watkins, all of them presenting beautiful ice-worn domes. The high spurs descending from Mount Watkins are finely terraced in front and sharply truncated on the crest.

From Moeraki to Oamaru, and thence northward to Timaru, the surface of the land everywhere bears the impress of ice erosion, and no one can view the landscape, with its beautiful smooth contours, domed and truncated crests, without being struck with the small part fluviatile erosion has played in modifying the ice-worn surfaces of the Glacial period.

The floor of the Shag Valley from Bushey Park to the river, as first shown by Captain Hutton, is occupied by glacial clays.

The Waitaki is a U-shaped glacial valley. The great glacier which occupied this valley descended from the main divide to the present coastline. It filled the Mackenzie Plain, occupying the present site of lakes Tekapo and Pukaki. It received great accessions from the Hopkins, Hobson, and Ahuriri. It scooped out the basin of Lake Ohau, and ploughed out the tiers of glacial shelves seen on the slopes of the adjacent ranges

The Waitaki glacier received its chief accessions from the Tekapo, Pukaki, and other basins that were filled with gigantic glaciers the surface of which, judging from the ice erosion and truncation of the mountains around the Mackenzie Plains, of the ranges lying east and west of Lake

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* J. Christie, *Otago Daily Times*, May, 1909.

Pukaki and bounding the Jollie River, stood at a height of 6,000 ft. above the sea.

The Omarama Basin was the gathering-ground and centre of movement of the ice-sheet in this region. From Omarama a stream passed southward through the Lindis Pass, joining the Clutha glacier a short distance above Bendigo; but the main Waitaki glacier turned eastward, flowing down the present valley to the sea.

The ice surmounted and flowed around the south side of Kurow Hill, at the mouth of the Hakataramea River, its course being clearly marked by ice-shorn surfaces and morainic drift for some six miles below the junction of that river, as first noted by Haast. The present gorge of the Waitaki River from Kurow to Awakino is of post-glacial date, the old glacial valley lying behind Kurow Hill.

On emerging from the mountains the Waitaki glacier, which was 118 miles long, deployed to the north and south, to the southward passing over and deeply eroding the triangular area of older marine Tertiaries lying between Oamaru and the Kakanui Range; to the northward flowing over the foothills lying between the Hakataramea and Waimate.

The hills along the seaward front of the Waitaki glacier are covered with a thick deposit of yellowish-brown clay or loess. In a few places near Oamaru, and on the old Holmes Estate, the loess contains intercalated beds of gravel; and along the present sea-face, from Oamaru past Cape Wanbrow to the mouth of the Awamoa Stream, a bed of beach-gravel containing many recent marine shells occurs at its base.

The Tertiaries on the north side of the Waitaki are truncated into plateau-like hills and ridges, while the spurs on the side of the range behind Waimate are in places excavated into glacial shelves, and everywhere exhibit beautiful, smooth, flowing contours. Behind Waimate the glacial shelves extend along the flank of the range for thousands of yards, about half-way up to the summit.

The Rangitata, Ashburton, Rakaia, and Waimakariri valleys are, as reported by Haast and Speight, U-shaped valleys, the present deep channels in which the rivers in places run having been excavated along the floor of the glacial valleys since the close of the glacial period. Where these rivers emerge from the mountains the spurs and slopes are, as noted by Haast, Hutton, and Speight, ice-shorn and truncated, and in places terraced to a height of 3,500 ft. or 4,000 ft. above sea level. The ice must have stood 1,000 ft. or more above that level to give it effective eroding-power at the 3,500 ft. contour. But even if we assume that the surface of the ice stood no higher than 3,500 ft., it is obvious, on gravational grounds, that the Waitaki, Rangitata, Rakaia, Ashburton, and Waimakariri glaciers, when they deployed from their mountain gorges, must have united into one great ice-sheet that presented a continuous face towards the sea along the present site of the Canterbury Plains.

Haast estimated, from the evidence of glacial terraces and *roches moutonnées*, that the Waitaki glacier was about 5,000 ft. thick in its middle portion.

The evidences of ancient glaciation on the east side of the main divide are conspicuous at Lake Coleridge, in the Rakaia Valley; at Lake Sumner, in the Hurunui Valley; at Lake Guyon, in the Upper Waiau; at Lake Tennyson, in the Upper Clarence; at Lake Rotoroa, in Nelson; and at Boulder Lake, in Collingwood. At these places, it should be noted, there are no existing glaciers. The mammillated Gouland Downs; the ice-shorn Whakamarama Range; the domed crests of Lead Hill and Mount Olympus; the beautiful *roches moutonnées* at Boulder Lake—itself a perfect rock-basin; and the glacial drift scattered over the Aorere Valley, afford conclusive proof that the Pleistocene glaciers of the South Island reached as far north as Cook Strait in latitude 41° S.

But Pleistocene glaciation was not confined to the South Island. There is abundant evidence that a large portion of the Province of Wellington suffered intense glaciation in that period. In the month of July of this year I examined a portion of the Rangitikei Valley and country lying around Mount Ruapehu. When I examined this region in 1886–87 it was covered, except in the Inland Patea and Murimotu plains, with a dense, almost impenetrable, forest, with few tracks or means of access. The construction of the Main Trunk Line Railway, the spread of settlement, and the clearing of the forest now render the examination of the topography and geology comparatively easy.

From the slopes of Ruapehu and Kaimanawa mountains the country is occupied by soft marine blue clays of Pliocene age, containing a thin band or two of rubbly shelly limestone. The surface of these rocks has everywhere the distinctive features of a land-surface subjected to ancient glaciation. The smooth, flowing outlines, the hummocky and mammillated valley-bottoms, the truncated crests, the terraced slopes, are always present.

The Rangitikei is a U-shaped glacial valley, as also is that of its tributary the Hautapu. The south and west slopes of Ruapehu are drained by the Wanganui and Wangaehu rivers; but it is obvious that a stream of ice no less than 4,000 ft. or 5,000 ft. thick flowed from the Karioi Basin across the divide into the Hautapu Valley, joining the great glacier that filled the Rangitikei Valley, a few miles south of Taihape.

The course of the Hautapu glacier is marked not only by the characteristic erosion of moving ice, but by the sheet of volcanic *débris* spread along its course for a distance of nearly thirty miles. The *débris* is mainly composed of erratic blocks of various andesites transported from the slopes of Ruapehu. It varies from 0 to 60 ft. thick, as seen in the railway cuttings; and surmounts the hills and ridges bounding the old glacial valley, forming a more or less continuous sheet, everywhere resting on a deeply eroded surface of the underlying marine clays or papa. Near Ruapehu that is, in the Karioi Basin the till is mainly composed of clays, blocks of andesite being absent or seldom numerous; but after crossing the divide into the Hautapu the blocks or boulders become more and more abundant, until in the lower twenty miles of the valley they compose the bulk of the till. Below Taihape they become less and less numerous, and are seldom seen as far down as the junction of the Hautapu and Rangitikei. The blocks are always angular, and vary from small pieces up to masses 6 ft. and 8 ft. in diameter. The largest blocks are more numerous at the southern limit of the deposit than elsewhere.

In many places the Hautapu has cut its way through the glacial drift into the underlying papa, and in the progress of this erosion has formed beds of resorted andesitic gravels that are well exposed on the banks of the main stream near Turanga-a-rere and other places. These gravels also contain well-worn greywacke pebbles brought down by the branches of the Hautapu that reach northward to the Kaimanawas. The difference between the tumbled rubbly glacial sheets of angular andesite blocks lying over hill and dale, and the recent gravels derived from it by erosion, is so conspicuous that it seems hardly possible for the one to be mistaken for the other.

The area at present known to be covered with this glacial till is some two or three hundred square miles, but it is not improbable that the clearing of the forest will show that it stretches far to the westward of the Hautapu.

The Rangitikei glacier descending from the Kaimanawa Range carried only greywacke blocks, and on account of its greater mass it forced the Hautapu glacier to the westward. The effect of this deflection is well seen in the fluvio-glacial drift that forms the great coastal plain extending from the Manawatu to the Wanganui Valley. In the Manawatu area the drift is entirely composed of greywacke material; in the Rangitikei area, of greywacke and andesite, the former predominating; while in the Wanganui area the boulders are mainly andesitic.

In the North Island the evidence of ancient glaciation has been described by me as far north as 39° 15′ S. latitude, and I am strongly of the belief that further investigation will extend the northerly limit considerably beyond this.

When discussing my paper on the glaciation of Ruapehu region and Rangitikei Valley,* Dr. Marshall dissented from my views both as to the evidence of glacial erosion and the glacial origin of the sheet of andesitic detrital material covering the Hautapu Valley. It is, of course, open for any one to dissent from my interpretation of the genesis of the surface forms—the acceptance of evidence as to glacial erosion is proportional to the observer's ability to interpret aright the signs of extinct glaciers; but in respect to the sheet of andesitic material the case is altogether different. When I discovered this deposit in 1886, so numerous, large, and angular were the piles of andesitic blocks of which it was composed, as then exposed in slips and where cut through by streams, in the dense forest then covering the Hautapu Valley, that I described† and mapped it as "volcanic agglomerate and tuff," derived either from some local volcanic centre or from Ruapehu. I am confident that any one who now views the piles of angular volcanic material exposed in the railway cuttings along the Main Trunk line between Mataroa and Taihape will pardon the error I unwittingly fell into in the year 1886.

Dr. Marshall also objected to the glacial origin of the till because I had made no mention of the occurrence in it of perched blocks. This was merely an omission on my part. As a matter of fact, many large erratic blocks of andesite occur perched on the slopes and summit of the papa hills near Kaikoura Stream, a short distance south-west of Utiku—that is, at the extreme south limit of the deposit, over forty miles from Ruapehu.

He further objected that no striated boulders had been found in the drift. So far no striated stones have been seen, and I think it is improbable that such will ever be found, as the underlying papa or blue clay is so soft that it could not, in my opinion, offer sufficient resistance to cause the striation of the harder andesite blocks dragged along by the ice.

But striated blocks are not always present in glacial deposits, their occurrence depending on the character of the bed-rock and the resistant character of the transported blocks. The Taieri Moraine, for example, contains no striated boulders, and their absence has not been advanced by any one as an argument that the deposit is non-glacial.

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* J. Park, "On the Glaciation of Ruapehu and Rangitikei Valley, Wellington," read before Otago Institute, 10th August, 1909.

† J. Park, "On the Geology of the Western Portion of Wellington Province and Part of Taranaki," Rep. Geol. Exp., 1886–87, p. 69.

Dr. Marshall[*] agrees with me that the material in the Hautapu glacial drift has been derived from Ruapehu, but says it is a river-gravel. I am confident that no one who has examined this deposit could possibly mistake it for a river-gravel; and I can only assume that Dr. Marshall has never seen the angular, rubbly, high-level andesitic glacial till discovered by me, and so well exposed in the railway cuttings, or that he has mistaken the resorted stream-gravels on the banks of the Hautapu and its tributaries for the glacial deposit itself. I have elsewhere stated that these stream-gravels are merely a local rewash of the great andesitic glacial deposit formed at the places where the streams have cut through it.

As Dr. Marshall still maintains that the glacial drift in the Hautapu Valley is a river-gravel, it becomes necessary to state the criteria of a river-gravel as defined by recognised authorities. They are as follow:—

(*a*.) The material is water-worn, and becomes more and more rounded as it travels away from its source.

(*b*.) The material is coarsest near the source, and gets finer and finer with increasing distance from the source.

(*c*.) The material is sometimes sorted into irregular beds that often exhibit current-bedding.

Judged by these criteria, we find that the Hautapu glacial deposit is everything that a river-gravel should not be.

In the first place, the material is not water-worn, but angular; and, in the second place, it is not coarsest near its parent source, but at its extreme south limit. It contains but little water-worn material, but, where typically developed in the Hautapu Valley, consists of a rock-rubble of angular andesite blocks, set in a matrix of gritty sands and rubbly clays.

The first to state that Otago was covered with a continuous ice-sheet was Mr. J. T. Thomson,† for many years Chief Surveyor of Otago, and afterwards Surveyor-General of New Zealand. Mr. Thomson was a keen student of the development of the surface-forms and topographical features, and brought to New Zealand a knowledge of the evidences of ancient glaciation as seen in Scotland, and of the work of valley glaciation in the Himalayas in India. By profession, by natural bent and experience, Mr. Thomson was perhaps better qualified to express an opinion on the glaciation of Otago than any other physiographer since his time.

In a letter to the *Otago Daily Times* of the 13th May, 1909, criticizing my presidential address to the Otago Institute, Dr. Marshall states that Mr. Thomson "went hot-headed for the covering of the whole southern portion of the Island with an ice-sheet." I hold no brief for Mr. Thomson, but, as one who knew him and the thoroughness of his work, I have no hesitation in saying that Dr. Marshall's statement does less than justice to the temperament and mental attitude of Mr. Thomson, who was an accomplished geographer and distinguished mathematician. Mr. Thomson was no hot-head, nor were his views as to the ancient glaciation of Otago hot-headed or precipitate, for he tells us that his conclusions as to the glaciation of the South Island were arrived at as the result of observations extending over seventeen years. In a paper read before the Otago Institute* in 1873 he made special mention of the furrowing of the hills and ranges so remarkably general in Otago.

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[*] P. Marshall, *Evening Star*, Dunedin, 12th August, 1909.

† J. T. Thomson, Trans. N.Z. Inst., vol. vi, p. 312; 1876.

Mr. Thomson's view as to the magnitude of the ancient glaciation of Otago did not receive the support of Hutton or Hector; but the only active opposition, except as to the striated boulders at Kaikorai Valley, came from Mr. W. T. L. Travers, the well-known advocate, of Wellington. Mr. Travers disagreed with Thomson's views, but did not visit Otago or even challenge the facts adduced by the latter as to the evidence of ancient glaciation. He did not attempt to explain the origin of the smooth, flowing contours, the furrowed and truncated hills and ridges, or the morainic deposits. He merely contented himself with the general statement that in the South Island there was during the glacial period a great extension of the valley glaciers, but no ice-sheet.

Mr. Travers, in discussing the cause of the greater extension of the glaciers, thought it was due to an elevation of the land amounting, in his opinion, to 5,000 ft. or 6,000 ft. In dealing with the glaciation of Otago, I only asked for an uplift of 3,000 ft. The 5,000 ft. or 6,000 ft. uplift conceded by Travers will do all and more than all Thomson asked for. In the first place, it would lower the mean temperature of the South Island below freezing-point throughout the whole year; and, in the second place, it would unite New Zealand with the Antarctic continent by a nearly continuous land connection. With such a low temperature and increase of land-area it is obvious that not only the South Island, but in all probability the greater portion of the North Island, would be in the grip of King Frost and dominated by ice.

Dr. Marshall objects to the silts or clays of Oamaru and Timaru being given a glacial origin. He states that we have the authority of Haast, Heim, Hardcastle, and others that they consist of wind-blown dust or loess. But to say the silts are loess does not disprove their glacial origin. The origin of the loess of Northern China, Russia, and North America has, like that of New Zealand loess, been a subject of keen discussion. Some have maintained that it was purely wind-blown, others that it was of subaqueous origin; but all have recognised that wherever it was found it occurred in the neighbourhood of glaciated regions. Sir Archibald Geikie† and other geologists believe that it is "a flood-loam of glacial times."

Writing of the loess deposits of Europe, Geikie says the vast accumulations of loess in southern and south-east Russia doubtless owe their origin chiefly to the flood-waters escaping from the margin of old land-ice.

Chamberlin and Salisbury‡ say that "The best-known portions of the loess in America and Europe are associated with glacial formations."

The contention that the clays of Oamaru and Timaru are loess is, after all, a proof of their glacial origin, which adds further confirmation of my contention as to the extension of the Pleistocene glaciers towards the present coast-line.

The thickness of the ice-sheet at the lower end of Lake Wakatipu was not less than 7,000 ft.—was probably much greater. But, taking it at 5,000 ft., it would surmount everything between that place and the east coast; and the smooth contours, domed crests, and U-shaped valleys in Southland and eastern Otago would indicate that this was actually the case.

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* J. T. Thomson, Trans. N.Z. Inst., vol. vi, p. 312.

† A. Geikie, "Earth Sculpture," p. 192; 1902.

‡ Chamberlin and Salisbury, "Geology," vol. iii, p. 405.

The maximum thickness of the ancient ice-sheet in North America has been estimated at 7,000 ft.; and the southern limit of the ice in Illinois was not less than 1,500 or 1,600 miles south of the Labradorian* centre of movement, reaching down to 37° 30′ N. latitude.

The distance from the Livingstone centre of movement west of Wakatipu to the present east coast is about a hundred and ten miles, and from Kingston about eighty-five miles.

If the North American ice-sheet, 7,000 ft. thick, was able to travel 1,500 or 1,600 miles from its centre of movement, does it seem impossible for the Wakatipu sheet, 6,000 ft. thick at Kingston, to travel a hundred miles? The answer is that it not only reached the present coast-line, but in all probability extended far beyond it as the result of gravitation stress.

Nansen found that the surface of the Greenland ice-sheet rose with a steep gradient at either margin, and flattened as the summit was reached. In the central parts of the icefield he found that the gradient varied from 26 ft. to 27 ft. per mile. For larger sheets Chamberlin and Salisbury† believe that the slope was probably less.

Discussing the thickness of the ice-sheet that covered northern Europe, Geikie‡ says that the ice may have been 6,000 ft. or 7,000 ft. thick in Scandinavia, and 4,000 ft. or 5,000 ft. as far south as Scotland, where ice grooves have been found at a height of 3,000 ft. above the sea.

Now, we know that the southern limit of the ice-sheet in Great Britain was the Thames Valley, a distance of over three hundred miles from the Scottish Highlands—the centre of movement. This distance has an important bearing on the gradient of the ice-sheet, for, if we take the thickness at 5,000 ft., it is obvious that the gradient of the British sheet must have been only 1 in 17.

If we take 500 ft. as the height of the abruptly sloping ice at the terminal face of the Otago ice-sheet, we have a vertical height of 5,500 ft. remaining; which, with a gradient of 50 ft. per mile, would give a flow of 110 miles, more than the distance from Wakatipu to the present coastline. The Labradorian ice-sheet that extended southward to the mouth of the Missouri could not have had a gradient exceeding 5 ft. per mile, except we are to believe that the thickness of the ice-sheet greatly exceeded 8,000 ft., which Salisbury says was not the case. With a gradient of 20 ft. per mile, the thickness would amount to the exaggerated thickness of 32,000 ft. The gradient of 50 ft. per mile I have assumed is probably far in excess of the actual mean gradient of the Otago ice-sheet.

It is noteworthy that Captain Hutton, in his map of the ancient glaciated area§ of New Zealand, shows nearly half of the South Island covered with a continuous ice-sheet.

My discoveries in the Wakatipu region in 1907-8 prove that the glaciation of the South Island attained a magnitude hitherto unknown to Hutton and other New Zealand geologists. My own view of the

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* Chamberlin and Salisbury, "Geology," vol. iii, p. 357.

† Chamberlin and Salisbury, "Geology," vol. i, p. 358.

‡ A. Geikie, "Geology," vol. .

§ F. W. Hutton, pamphlet, "Report of the Research Committee appointed to collect Evidence as to Glacial Action in Australasia in Tertiary or Post-Tertiary Times," p. 12.

New Zealand glacial period up to the year 1907 was the same as that of Hutton; but the fresh evidence discovered at Wakatipu and Wanaka, a re-examination of the glaciation of the coastal land between the Clutha and Canterbury, and the glacial deposits of the North Island, have led me to the belief that the glaciation of New Zealand was on a scale too gigantic to be accounted the work of valley-glaciers. Hutton has shown that nearly half of the South Island was glaciated with an ice-sheet. I have ventured, in the light of fresh evidence unknown to Hutton, to extend the limits of the glaciation over the greater portion of the South Island.

I am in agreement with Hutton and Hector that the glaciation was caused by a general elevation of the land, the uplift amounting to 3,000 ft. or more. This elevation would extend the limits of New Zealand many hundreds of miles to the eastward, and six or seven hundred miles to the southward, the southward limit reaching within seven hundred miles or less of the Antarctic continent. If the New Zealand uplift affected the south polar region, then glacial New Zealand would be separated from the Antarctic land by a relatively narrow stretch of sea.

The question that at once arises is, could New Zealand suffer such intense glaciation without lands in the same latitudes in other parts of the Southern Hemisphere being equally glaciated? The evidence on this point is clear and emphatic, leaving to my mind no further room for doubt that the whole of the higher latitudes of the Southern Hemisphere were glaciated contemporaneously with the Pleistocene glaciation of the Northern Hemisphere.

The land-areas that extend southward to the glaciated latitudes of New Zealand are South America and Tasmania. It will be interesting to see what is said by recognised authorities as to the glaciation of these lands.

The glaciation of Tasmania in the Pleistocene has now been placed beyond all doubt. Evidence of glacial action in that State was first discovered by Mr. Charles Gould,* in the Cuvier Valley, and reported by him in 1860; but, though challenged and denied for some years, the high-level glaciation was at last established by Dunn and Moore. Mount Tyndall, on the authority of Moore, is polished and striated at an altitude of 3,850 ft. Mr. A. Montgomery, sometime Government Geologist of Tasmania, has described important glacial phenomena in the vicinity of Mount Pelion and Lake Eyre. Morainic deposits and perfect *roches moutonnées*, together with erratics, are described by him as traceable from 2,000 ft. to 2,792 ft. above the sea.

The West Coast Range, Eldon Range, and Mount Ida were covered with glaciers which flowed westward into the valley of the King River, the Macintosh River, and the Henty. The lowest moraines formed by these glaciers, on the authority of Professor Gregory, occur at a height of about 400 ft. above the sea. This is confirmed by Professor David, who states that in the Pleistocene time the glacial ice came to within a few hundred feet of sea-level, if not down to sea-level itself. Important contributions to the glaciation of Tasmania have also been made by Johnston, Twelvetrees, Kitson, Waller, and others. An excellent summary of glacial action in that State and in Australia is given by Mr. Johnston† in a paper on the "Glacial Epoch of Australasia."

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* C. Gould, "A Report of the Exploration of the Western Country," Parl. Paper, Tasmania, No. 6, 1860.

† R. M. Johnston, Papers and Proceedings, Royal Society of Tasmania, 1893.

Evidences of ancient glaciation have been also discovered in Victoria, New South Wales, and South Australia.

In 1872, Professor Agassiz, the celebrated Swiss naturalist and glacialogist, as the result of his explorations, announced that the southern portion of the South American continent, as far north as 37° S. latitude—that is, for a distance of nearly 1,100 miles north of Cape Horn—was covered with a continuous ice-sheet extending from the Atlantic to the Pacific Ocean.* He stated that the movement of the ice was to the north, and independent of the present slopes of the land.

But, long prior to this, Darwin had called the attention of geologists to the thick masses of boulder-clay and other evidences of glaciation at Tierra del Fuego; while, in 1870, Professor Dana,† a distinguished American geologist, in his well-known work on "Geology," had stated that glacial drift in South America is met with as far north towards the Equator as 41° S. latitude.

Professor Agassiz was the father and exponent of the theory of ancient glaciation of northern Europe and America. It was he who in 1840 startled the geological world with the announcement that northern Europe had been another Greenland, lying under a continuous sheet of land-ice—a conclusion arrived at as the result of a close study of the European Alps.

The clamorous opposition to his views regarding the invasion of the polar ice-sheet, mostly advanced by zoologists, was soon silenced; and in the early "forties," as a result of a tour through Scotland, accompanied by the veteran Dr. Buckland, he further announced that the northern kingdom everywhere contained clear evidence of ancient glaciation.

Subsequently, Darwin, Buckland, Sir Charles Lyell, Sir A. C. Ramsay, Sir Archibald Geikie, and Professor Geikie verified the conclusions of Agassiz, and made fresh discoveries in England and North Wales, which, in the late "forties," led to complete agreement among British geologists as to the Pleistocene glaciation of Great Britain and Ireland by a sheet of land-ice which was an extension of the north polar ice.

Agassiz carried his observations to America, and in the early "fifties" reported the discovery of evidence showing that a continuous ice-sheet had extended down the Missouri Valley as far south as 41° N. latitude—a conclusion now accepted by all American geologists. Later discoveries have shown that the southern limit of the Labradorian‡ ice-sheet reached as far as 37° 30′ N. latitude.

The opinion of Agassiz, announced in 1872, that the Southern Hemisphere had passed through a glacial period, or great Ice Age, in all respects parallel with that in the Northern Hemisphere, is quoted approvingly by Sir Archibald Geikie in his monumental text-book, by Professors Chamberlin and Salisbury in their comprehensive manuals, by Professor Prestwich in his well-known text-book; and is challenged by none. On the contrary, Prestwich in his glacial map of the Antarctic region shows the southern portion of South America as glaciated with a continuous ice-sheet up to 37° S. latitude, contemporaneously with the Glacial period of the Northern Hemisphere. On the same map he shows that the greater portion of the South Island of New Zealand was glaciated at the same time.

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* Am. Jour. Sc., vol. iv, p. 135; 1872.

† J. D. Dana, "Geology," 2nd ed., p. 540; 1870.

‡ Chamberlin and Salisbury, "Geology," vol. i, p. 330.

Speaking of the evidences of ancient glaciation in South America, Professor Prestwich* says, "Those facts are nevertheless decisive as to the prevalence in late geological times of a glacial epoch which there is reason to suppose was synchronous in the two hemispheres."

If the Southern Hemisphere suffered a period of glaciation synchronous with that of the Northern Hemisphere, how could New Zealand escape? South America shows clear evidence of ice invasion as far as 37° S. latitude: why not look for similar evidences in corresponding latitudes in New Zealand? My discoveries of gigantic and hitherto unrecorded evidences of glaciation in the South Island and in the Province of Wellington seem to show that New Zealand did participate in the general glaciation of the Southern Hemisphere as far north as 39° S. latitude.

Speaking of the criteria of glaciation, Professors Chamberlin and Salisbury† say, "It is not strange that the glacial theory was resisted half a century." It is perhaps not strange to find resistance still alive in this remote Dominion, where the modern thought of the northern world must of necessity permeate slowly, and take time to find a place in our literature.

Having shown that the South Island and a portion of the North Island were glaciated during the Pleistocene, I have ventured to suggest that the glaciation was caused by a general uplift of the land to the extent of 3,000 ft. or more—an uplift giving New Zealand continental dimensions, and bringing it close to the Antarctic land. The natural corollary of this hypothesis was my suggestion‡ that the glaciation of New Zealand was caused, or, at any rate, accompanied, by an advance of the Antarctic ice-sheet in the same manner as the Glacial epoch of northern Europe was caused by an invasion of the Arctic ice-sheet, which was followed by a great extension of the Alpine glaciers.

The distance from New Zealand to Wilkes Land is 1,320 miles, or about the same distance as Melbourne. The Campbell, Auckland, Macquarie, and other subantarctic islands stand on the same marine platform as New Zealand, and, according to Sir Joseph Hooker§ and Captain Hutton,‖ were at one time a continuation of that area. As we have already seen, New Zealand geologists are agreed that the Glacial period was caused by elevation of the land, the majority—myself included—agreeing that an uplift of 3,000 ft. or 4,000 ft. was required to give the necessary refrigeration. It is obvious that an uplift of that amount would link up all the southern and outlying islands with the mainland of New Zealand, thereby reducing the sea gap between glacial New Zealand and the Antarctic land to less than seven hundred miles, besides correspondingly reducing the depth of the sea in the intervening gap.

If the New Zealand elevation was accomplished by uplift in the Antarctic to a corresponding extent, then Ross Sea,¶ which is relatively shallow, would be dry land, thereby still further reducing the stretch of water intervening between the extended New Zealand area and the Antarctic continent.

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* Prestwich, "Geology," vol. ii, p. 465.

† Chamberlin and Salisbury, "Geology," vol. i, p. 337.

‡ J. Park, "Glaciation of Wakatipu Region," Bulletin No. 7, N.Z. Geol. Surv., 1909: and presidential address to Otago Institute, 12th May, 1909, "On the Block Mountains and Great Ice Age of New Zealand," *Otago Daily Times*, 12th May, 1909.

§ Ross, "Voyages," vol. i, p. 160; 1847.

‖ Hutton, Trans. N.Z. Inst., vol. xxxii, p. 182.

¶ Dr. K. Fricker, "The Antarctic Region," p. 208; 1900.

Dr. Marshall* states that in the "most highly glaciated tracts the ice does not extend over deep-sea areas." This statement is entirely contrary to well-attested facts. In the Antarctic region the Great Ice Barrier extends over the sea for many hundreds of miles.

Ross† found a depth of over 2,160 ft. on the edge of the barrier, and, commenting on this, he says, "So great a depth of water seemed to remove the supposition that has been suggested of this great mass of ice being formed upon a ledge of rock, and to show that its outer edge, at any rate, could not be resting on the ground."

Further on‡ he mentions the almost magical power of the sea in breaking up land-ice or extensive floes from 20 ft. to 30 ft. thick; but this extraordinary barrier of ice of probably more than a thousand feet in thickness crushes the undulations of the waves and disregards their violence. It is, he says, "a mighty and wonderful object, far beyond anything we could have thought or conceived."

Captain Scott, of the "Discovery" Expedition,§ found soundings ranging up to 482 fathoms, or 2,892 ft., on the edge of the ice barrier, concerning which he says, "What was the thickness of the ice-sheet to the south, or what lay beneath it, was obviously impossible for us to determine; but on collecting all the indirect evidences which bear on these points, I came to the conclusion which I still hold that the greater part of it is still afloat; and, strange as it is to imagine that the sea should run beneath such a solid sheet for so many hundreds of miles, I have yet to learn any reasonable argument against such an idea."

The ice-sheet stretched far beyond the most southerly point reached by Scott. Its extent is perhaps not less than five or six or even seven hundred miles.

Speaking of the former extent of the ice-sheet, Scott‖ says, "On all sides of us and everywhere were signs of the vastly greater extent of the ancient ice-sheet."

In the Glacial epoch of the Northern Hemisphere the ice-sheet extended across the North Sea for many hundreds of miles, until it reached Scotland.

Referring to the former extension of the ice-sheet in Ireland, Geikie¶ says, "There can be no doubt from this evidence that even in the south of Ireland the ice-sheet continued to be so massive that it went out to sea as a great wall of ice."

The Antarctic Ice Barrier still extends over the sea as a solid sheet "for many hundreds of miles," even though the Glacial period there is now past. Have we any reason to believe that it did not extend seven hundred miles farther north—that is, to the limit of the extended New Zealand area—during the period of maximum refrigeration?

Or, even assuming the Glacial period to have been due to some other cause than elevation of the land, do we know of any reasonable argument why the ice-barrier in the Glacial period could not extend over the sea for the 1,300 miles that separates New Zealand and the Antarctic land? On the contrary, it seems only reasonable to suppose that the intense refrigeration which caused the gigantic glaciation of New Zealand would assist the ice barrier to invade these latitudes.

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* P. Marshall, *Otago Daily Times*, 13th May, 1909.
† Ross, "Voyages," vol. i, p. 222.
‡ *L.c.*, p. 228.
§ Scott, "Voyage of the 'Discovery,'" vol. ii, p. 309.
‖ Scott, *l.c.*, p. 314.
¶ A. Geikie, "Geology," vol. ii, p. 1329.

The extent of a marine ice-sheet would seem to be mainly dependent on the degree of refrigeration. It is difficult to see where the depth of the sea comes in when once the ice is afloat, except it be supposed that the ice can only advance where it rests on the sea-floor. But Ross, Scott, and others have shown the fallacy of this contention, proving by soundings that the Antarctic ice barrier in Ross Sea is afloat, as stated above, for many hundreds of miles.

Dr. Marshall* further objects that no boulders foreign to New Zealand have been found in any glacial deposit. In making this statement Dr. Marshall must surely have failed to recognise the fact that the movement of the ice in the New Zealand area would everywhere be away from the centre of movement, at the main divide, towards the sea. I never suggested that the Antarctic ice advanced to New Zealand and crept over its highlands and mountains. Polar ice cannot disregard the laws of gravitation. Ice obeys all the laws of motion of a viscous fluid, and hence flows away from the gathering-ground to a lower level like a slowly moving river. Obviously, as the New Zealand land-ice alone flowed over Otago, it would be futile to look for Antarctic boulders in the local moraines, as the pressure of the land-ice would certainly keep the Antarctic sea-ice away from our shores.

The local origin of morainic drift, or till, is emphasized by all writers of text-books on geology. Thus Sir Archibald Geikie,† in his text-book, says, "The great majority of stones in boulder-clay are of local origin, not always from the immediate adjacent rocks, but from points within a distance of a few miles." Further on he says,‡ "No Scandinavian blocks have been met with in Scotland, for the Scottish ice was massive enough to move out into the basin of the North Sea until it met the northern ice-sheet streaming down from Scandinavia, which was kept from reaching the more northerly parts of England."

Again, he says, on the authority of Professor Salisbury, that the general local character of the glacial drift is as marked in Canada and the United States as in Europe.

In other words, blocks can only be carried from their gathering-ground, or centre of movement, within the limits of flow of the ice-stream, and in all cases the pressure of land-ice will be superior to that of ice supported on water.

Boulder-clays or till, and all infraglacial drifts, must from their mode of formation be composed of rocks of local origin. On the other hand, the rocky material borne on the back of the glacier or interbedded in an ice-sheet may be carried a great distance from the parent rock.

British geologists recognise two distinct epochs of glaciation in the late Tertiary, separated by an interglacial period of milder climatic conditions —namely, an older epoch during which Scotland and the greater part of England were covered with an ice-sheet, and a later epoch of less intense refrigeration than the first, as shown by the more local character of the glaciation. The last was distinguished by many minor phases of intensity.

As far back as 1876 Captain Hutton§ also distinguished two epochs of glaciation in the late Tertiary in New Zealand. To the older, or period of maximum refrigeration, he ascribed the Taieri Moraine and Blue Spur deposits, and to the younger the terminal moraines scattered throughout Otago, as well as the Kaikorai and Shag Valley deposits. Hutton's view has been supported by Mr. Hardcastle,* of Timaru.

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* P. Marshall, *Otago Daily Times*, 13th May, 1909.

† Sir Archibald Geikie, "Text-book of Geology," vol. ii, p. 1310.

‡ *L.c.*, p. 1311.

§ F. W. Hutton, "Geology of Otago," 1876, pp. 62–67.

I am entirely at one with these writers in distinguishing two epochs of late Tertiary glaciation in New Zealand. To the older period I ascribe the Blue Spur, Taieri, and Kaikorai glacial deposits in Otago, and the great andesitic boulder-till in the Rangitikei Valley in Wellington; and to the later epoch the valley moraines, glacial dams, and fluvio-glacial drifts in the South Island. The first was the period of maximum refrigeration, causing widespread glaciation; the second, the epoch of gigantic valley glaciers, which showed many minor advances and retreats before the last and final recession to the Alpine strongholds.

The parallelism between the Glacial epochs of Great Britain and New Zealand is too remarkable to be a mere coincidence, and would tend to show that the refrigeration of the Pleistocene was due to some secular cause, and not to local elevation, as New Zealand geologists have commonly believed.

In Europe a succession of great ice-sheets, radiating from north Norway as a centre, crept over the lowlands of northern Europe, and, crossing the basin of the North Sea, was met by the ice radiating from the mountains of Great Britain. The ice-sheets from the Scandinavian glacial centre also crept northward, joining the ice of the Arctic region.

In North America four centres of glacial radiation have been recognised—namely, the Greenlandian, Labradorian, Keewatin, and Cordilleran—the last three being situated in the continental area somewhere between the parallels 52° and 55° N. latitude. The Labradorian centre lay about 1,800 miles east of the Keewatin centre, and the Cordilleran about 1,000 miles west of it. The ice-streams from these centres, though so far apart, united as they spread outward, covering altogether an area of some 4,000,000 square miles. The Cordilleran ice-sheet crept southward to 47° N. latitude; and the Labradorian to 37° 30′ N. latitude, or 1,600 miles from the place of dispersion. From these glacial centres the ice-sheets also spread northward, joining the advancing ice of the Arctic region.†

The evidence seems to leave little reasonable room for doubt that the Alpine region of the South Island was a centre of dispersion from which ice-sheets in like manner radiated outward towards the sea on all sides. The European and North American ice-sheets deployed northward, joining the Arctic ice. There seem to be no valid grounds for supposing that the New Zealand ice-sheets did not spread southward and join the advancing Antarctic ice.

CRITERIA OF GLACIATION.

Having thus reviewed the evidences of ancient glaciation presented in New Zealand, more particularly as seen in Otago and on the east coast of the South Island, and in the Provincial District of Wellington, we are better able to determine the value of the criteria of an ice-sheet mentioned by Dr. Marshall. He places these criteria under five headings, which I propose to consider seriatim:—

(1.) A continuous line of morainic deposits at the extreme limit of the ice-sheet.

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* Hardcastle, Trans. N.Z. Inst., vol. xxiii, p. 311.

† Chamberlin and Salisbury, "Geology," vol. iii, p. 331.

This is contradicted in England, where, as Geikie tells us, no terminal moraine marks the southern limit of the ice-sheet that crept over Britain. But in New Zealand we have the Taieri coastal moraine, for size without a parallel in any other part of New Zealand, or even in Great Britain; therefore the balance of evidence as to an ancient ice-sheet lies with New Zealand as against England, which, although possessing no terminal moraine, is admitted to have been covered with an ice-sheet.

(2.) The occurrence of till or boulder-clay over almost the whole area covered by the ice-sheet.

When tested against British experience we find that this criterion, like the first, also fails. In Scotland, although ice-covered in the Pleistocene from end to end, the till is mainly confined to the maritime benches, coastal plains, and lowland valleys. Altogether it does not cover more than 25 per cent. of the total area. England and Wales were covered with a continuous ice-sheet as far south as the valley of the Thames, and yet we find that the glacial drift is most irregularly distributed, altogether covering less than 12 per cent. of the glaciated area. In New Zealand we have the great Taieri Moraine, the Kaikorai boulder-clay, and the loess covering the coastal hills at Oamaru and Timaru, the Lyttelton Hills, and Motanau Downs; loess being, as we have seen, a deposit of purely glacial origin.

The Taieri Moraine is admitted to have been formed by a glacier that descended from the highlands between the Clutha and Taieri rivers. The glacier that filled the Taieri Basin and formed the great coastal moraine must have presented a front from thirty to forty miles long at the least. And, since this gigantic glacier surmounted hills over 1,000 ft. high near Milton, it must also have flowed southward into the lower Clutha Valley—a conclusion strengthened by the smooth, flowing contours and chain of shallow lagoons on the Clutha side. To those not familiar with the geography of this place, it should be mentioned that the rise between Milton and the Clutha Valley is only some 150 ft., the area between the Tokomairiro Plain and the lower Clutha being occupied by low, round, ice-shorn ridges varying from 200 ft. to 300 ft. above sea-level.

My object is to show that this Taieri ice-sheet must have been of gigantic proportions. Now, if the climatic conditions in the arid region of Central Otago allowed the accumulation of this great ice-sheet, what, I ask, must have been the climatic conditions on the higher, less arid mountainous region of western Otago? Would not that area, as already shown by Hutton, be also covered with a continuous ice-sheet? Dr. Marshall seems to have anticipated this difficulty, for he tells us—and this is only a hypothesis suggested by Geikie and Chamberlin—that the supposed non-glaciation of eastern Europe, Siberia, and Alaska was due to the aridness of the climate—that is, to the absence of precipitation. And from this he argues that one valley may contain a glacier and the next to it no glacier. Unfortunately for the application of this argument to New Zealand, the site he has selected for the gathering-ground of the Taieri ice-sheet is situated in the most arid region of Central Otago, where, as in Siberia, the snowfall should have been too small to maintain such a mass of ice as that which radiated from the highlands between the Clutha and Taieri watersheds, filled the Taieri and Tokomairiro basins, and crept over the coastal hills to the present coast-line.

I contend that the great ice-sheet that descended from the highlands of Central Otago was a part of the greater ice-sheet that occupied the Wakatipu and Wanaka areas.

If Dr. Marshall's second criterion were made to read that "a portion of the glaciated area is covered with till or boulder-clay," it would be nearer the truth, and be applicable equally to Great Britain and New Zealand.

(3.) The occurrence of rounded hills over the glaciated area.

This is admitted by geologists to be a common feature of glaciated areas. Rounded hills are conspicuous along the east coast of Otago from the Kakanui River south to Waikouaiti, and from near Dunedin south to the Clutha. Of examples north of Dunedin we have Hawkswood Hill, Bald Hill, and Mount Watkins on the north side of Waikouaiti Valley. There are many equally fine domed hills in the Palmerston district, but I have selected these, as they are well seen from any point on the railway near Puketeraki. South of Dunedin we have Saddle Hill, Scrogg's Hill, and Stony Hill; Waihola Hill and Tuna Hill on the west side of Lake Waihola - the first opposite Waihola Railway-station, the second at the south-west end of the lake; and farther south the beautiful rounded domes and whalebacked mounds near Crichton Railway-station, six miles south of Milton.

Maungatua is a good example of a domed hill when looked at from the Taieri Basin; but, as viewed in profile from any point south of Milton, it is found to present the characteristic features of the well-known "slope and crag" which is so distinctive of highly glaciated areas. Viewed from the Taieri Plain it appears to be a high mountain with steep slopes, but when seen in profile it appears as a fine dome sloping gently westward to the Barewood Plateau, on the edge of which it stands. On the east it descends suddenly into the Taieri Plain. The gentle slope is the *stoss-seite*, the steep slope the *lee-seite*.

(4.) The occurrence of grooved or ice-worn surfaces of rock throughout the district covered by ice.

Ice-worn surfaces, as I have already shown, abound on every hand, in some areas as smooth and fresh as if the ice had only yesterday retreated, but in most areas dissected and eroded by the younger present-day streams.

Of the undisturbed glaciated surface we find beautiful examples around Hampden, and immediately south of the Tokomairiro Plain, where between Crichton and Lovell's Flat the smooth, flowing outlines are still finely preserved on the long, gentle slope rising towards Central Otago.

Of the glaciated ice-worn surfaces that are more or less impressed with later stream erosion I will here mention only the splendidly ice-worn slopes on the west side of the Taieri and Tokomairiro plains, extending as far south as Lovell's Flat and Balclutha, a distance of altogether some forty miles. These smooth, gently rising slopes were eroded by the great ice-sheet that descended from the Barewood Plateau and the Clutha glacial valley, and can be seen to great advantage from the Main South Railway, more particularly on the west side of Lake Waihola and on the south-west side of the Tokomairiro Plain after passing Milton.

Recent streams have cut many narrow gutters and shallow gullies in the glaciated slopes; but the two generations of erosion can be easily traced by even the merest novice in physiography from the circumstance that the flat glaciated surfaces are generally covered with yellowish-coloured tussock, while the gullies worn out by later stream-action are commonly sharply outlined by the darker-coloured bracken that grows in them.

The evidences of glacial erosion are perhaps seen to better advantage on the west side of the Tokomairiro Plain than elsewhere in Otago. The panorama of ice-worn slope, rounded dome, mammillated ridge and hummock, as seen from the summit or slopes of Mount Misery, near Milton, is unsurpassed by anything in the Wakatipu district, or by anything I know of in Scotland or England.

Briefly stated, Dr. Marshall's fourth criterion postulates that the area covered by ice is grooved and ice-worn; and no one, I think, will be found to dispute it. Further on he admits that the Taieri Moraine was formed by an ice-sheet or glacier that descended from the highlands between the watershed of the Taieri and Clutha rivers.

The pertinent question is, does he deny the competency of this particular ice-sheet to erode the surface over which it flowed? Did it present an exception to the general law? I have, I think, sufficiently proved that the surface over which it flowed is, as we should naturally expect, deeply glaciated, and the evidence is there for every one to see.

> (5.) Boulders of rock foreign to the locality would be found in great numbers in positions where they could not have been deposited by streams that formerly existed, or on prehistoric sea-benches.

I have already quoted references from Sir Archibald Geikie and Professor Salisbury to show that the rocks in boulder-clays are of local origin. A large proportion of the boulders in the Taieri Moraine consists of rocks carried from the west side of the basin. The absence of foreign rocks in this moraine has not been held by Hector, McKay, or Hutton to be proof of its non-glacial origin. No rocks foreign to New Zealand have yet been found in the coastal moraines, and I think it improbable that such will ever be found. Geikie has shown that the pressure of the land-ice descending from the Scottish Highlands thrust the Scandinavian ice-sheet, flowing over the North Sea, away from the shores of Scotland; and it is certain that the Otago land-ice would in the same manner thrust the invading polar ice away from our shores.

Dr. Marshall states that diligent search for eight years has failed to show him on the coastal hills of Otago any of the evidences of glaciation that I have shown to be so abundant in the Wakatipu region. Perhaps, after all, this is not surprising when we remember that such veteran geologists as Sir Charles Lyell, Sir Roderick Murchison, Sir Andrew C. Ramsay, and Dr. Buckland failed to observe the widespread and conspicuous evidences of glacial action in Scotland until these were first brought under their observation by Agassiz.

The glaciation of northern Europe was at first denied by zoologists. It was claimed that an advance of the polar ice would have caused an overlapping of Arctic, Sub-arctic, and Temperate faunas. That some such overlapping did take place appears to have been established. Be that as it may, the difficulties of the zoologists have long since been removed.

The glaciation of the South Island and of a large portion of the North Island will doubtless present difficulties to the biologist. What these difficulties are I cannot suggest. All that I can do is to record the evidences of an ancient glaciation that occurred on a scale so great as to suggest that the South Island was a centre of movement from which the ice-sheet descended to the sea, in the southward direction probably meeting the advancing polar ice.

Art. LXII.—*A Geological Reconnaissance of Northernmost New Zealand.*

By J. M. Bell and E. de C. Clarke.

[*Read before the Auckland Institute, 22nd November, 1909.*]

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Introductory.

Introduction.

The northern portion of the North Auckland Peninsula is an area of both geological and geographical interest. The sedimentary strata differ considerably in lithological character, and also apparently in age. The igneous rocks, while showing marked diversity in texture, mineralogical character, and mode of origin, will probably be found to display a relatively close similarity in chemical composition. Several geographic cycles have passed over this sea-bordered area, each leaving its mark on the land.

The area may, for the sake of convenience, be called the Aupouri Peninsula, after the Maori tribe that formerly occupied it in considerable numbers.

A hurried reconnaissance of the Aupouri Peninsula made by us during the spring of 1908 had as its chief object the obtaining of a general conception of the main geological and geographical features for purposes of comparison with those of the Whangaroa Subdivision, further south, where detailed observations were at that time proceeding. The present paper is to be considered as a very imperfect summary of the geology of northernmost New Zealand.

Previous Investigations.

As early as 1840 Dieffenbach* visited the locality, but that energetic scientist Sir James Hector† was apparently the first to examine the area at all systematically. Later Mr. A. McKay,‡ the veteran geologist, carried out further geological surveys. Dr. Marshall,§ in recent papers, mentions very briefly some features of the Aupouri geology.

PHYSIOGRAPHY.

At the northern part of the Aupouri Peninsula a low, much-dissected tableland rises to a height of about 1,000 ft. This tableland seems to represent a portion of an old peneplain, which, formed in the Miocene period, has been tilted in many directions and elevated to varying heights since that time.

The tableland occupies a great portion of the peninsula north of the Harbour of Parengarenga. Southward of this inlet the tableland merges gradually into lower country, showing less-pronounced relief. Flat-topped hills, gradually decreasing in altitude, border the eastern seaboard to Hohoura, where the more elevated country forming Mount Camel marks the occurrence of an outcrop of harder and more ancient rocks. South of Parengarenga sandhills extend inland from the western sea-coast, and, south of Hohoura, cover the entire width of the peninsula.

It will be apparent from the foregoing description that the peninsula consists essentially of a northern rather rugged mass of hard igneous and sedimentary rocks connected, by a long low tongue of less-resistant rocks, to the main mass of the North Auckland Peninsula. The outline of the Aupouri Peninsula would therefore seem to have been determined largely by the varying character of the rocks that compose it.

The sequence of events indicated by the present contour of the Aupouri Peninsula is apparently similar to that which may be deduced from a study of the physiography of the whole of the North Auckland Peninsula.

The northern part of the Aupouri Peninsula has probably been subjected to atmospheric denudation since the close of Miocene times, when it was apparently reduced to a peneplain. Elevation since that time has caused subaerial agencies to renew their work—a work now far advanced, as is evidenced by the rounded contour of the hills, the general absence of rock-waste, and the sluggish, well-graded character of most of the streams. In comparatively recent times a depression has taken place, of which the drowned river-valleys now forming the harbours of Hohoura and Parengarenga are the most striking evidences. A slight elevation may now be in progress, but of this there is not as yet satisfactory evidence.

The Land.

The land-surface of the Aupouri Peninsula may conveniently be discussed under the following headings: (1) The tableland; (2) the low hills bordering the eastern seaboard; (3) the sand country.

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* "Travels in New Zealand," 1843, p. 199.

† "Geological Sketch-map of Northern District of Auckland."

‡ Rep. G.S., 1894: "On the Geology of Hokianga and Mongonui Counties, Northern Auckland."

§ "Distribution of the Igneous Rocks of New Zealand," Aust. Assn. Adv. Sci., 1907, p. 366; "Geology of Centre and North of North Island New Zealand," Trans. N.Z. Inst., vol. xl, p. 79.

(1.) *The Tableland.*—The surface of the tableland consists of uplands covered with scanty scrub, and trenched by rather steep-sided, well-graded valleys, often swampy. The valleys contain some standing bush, not generally of very good quality. The land-surface is generally free from rock outcrops, but along the sea-margin mural precipices rise in many places abruptly from the water's edge. Further description of this feature will be found in the account of the sea coast.

Near Cape Maria van Diemen, and thence southward towards Scott Point, that portion of the tableland which borders on the sea is cloaked with sand piled up by the prevailing westerly winds. In this part of the area the sand seems to be advancing rapidly, and after every gale the changes wrought by it in destroying vegetation, filling up hollows, and damming streams to form small temporary lakes are very apparent.

In Rahia Bay, where stratified Pleistocene sands and gravels, with peat-beds, outcrop on the shore, a rather remarkable topography is exhibited, resembling somewhat that of the Bad Lands of South Dakota. Here well-sculptured cliffs, with outstanding pillars of bizarre form, border the sea and extend up the narrow valleys (Plate LIII, fig. 2).

(2.) *The low hills bordering the eastern seaboard* form a practically even-crested ridge, rising almost imperceptibly from the sea-shore on the east and from the sand-waste on the west. Gentle undulations are, however, apparent in places, and shallow valleys occur at frequent intervals. Formerly—possibly before the advent of the Maoris dense kauri forest covered this part of the peninsula, but now a scant covering of scrub has replaced the luxuriant vegetation. The sand is encroaching on this part also, and producing the same effects as noted in the previous section. Doubtless the particularly mild relief of this portion of the area is due in part to cloaking by the sand.

(3.) *The sand country*, which extends eastward from the broad, hard, western Seventy-mile Beach, and, in smaller patches, inland from the eastern sea-beach, consists of rolling sand-dunes of gentle gradient on the windward side, but steep-sloped on the leeward side (Plate LIII, fig. 1). In the hollows between the more or less parallel ridges of sandhills small ponds of water occur. Ponds are also formed in the neighbourhood of the higher land where the ever-moving sands have formed dams across the streams. As these become filled with more wind-blown material, quicksands are formed, which may be dangerous to the traveller.

The Coast-line.

The coast-line of the Aupouri Peninsula is one of great variety, presenting marked divergence in character between the places where soft comparatively recent sedimentary strata occupy the coastal region, and where the resistant igneous and older sedimentary rocks confront the ocean. Along the western seaboard shifting sands alone appear, except at the extreme north. Thus an almost straight shore-line with a broad sand-beach, and with sand-dunes extending inland, borders the sea. The shore-line here, owing to the softness of the rocks, seems to have almost reached maturity.

The northern shore-line presents a series of gravel- or sand-bordered bays diversified by steep rock-precipices. The sunken stream-mouths and the occasional islets and skerries off the coast testify that the shoreline is recently depressed, and that it is consequently a young feature. That it is not absolutely infantile is proved by the numerous cliffs cut in the rocky ridges, by the marked rock-benches which occur in places (Plate LIV, fig. 2) and by the sand- and gravel-bays which represent aggraded sunken stream mouths (Plate LIV, fig. 1).

The eastern shore-line resembles the western margin. There are two pronounced indentations – the harbours of Parengarenga and Hohoura. Both are sunken stream-mouths. Parengarenga, with its branching bays, is of very irregular outline. At low tide the greater part of the inlet is bare of water, save for the channels of the numerous streams which ramify through the mud-flat and unite to flow as a single stream through the narrow entrance. Hohoura Harbour resembles Parengarenga in general character, but is smaller and of simpler outline.

Drainage.

The drainage of the Aupouri Peninsula is insequent in type – that is the streams flow independently of the structure of the rocks.

The area is well and maturely dissected. Many of the streams flow practically at grade to their headwaters.

The principal streams are the Waitiki, Mitimiti, and Te Kao, entering Parengarenga Harbour, and the Werahi and Waitangi, draining into the sea on the northern seaboard. All are short and small, as would be expected from the small area and low relief of the country they drain.

GEOLOGY.

Introduction.

Owing to the inspection of the Aupouri Peninsula being only in the nature of a reconnaissance, we were unable to investigate for ourselves many interesting questions dealt with in the reports of Sir James Hector and Mr. Alexander McKay. In order to present as complete an outline as possible of the geology, the remainder of this paper is partly a compilation from these previous reports, but in every case where the conclusions given are not the result of our observations the authority for them is quoted.

The following provisional names will be applied to the stratigraphical groups recognisable in the area under consideration: Mount Camel Series, Whangakea Series, Rahia Series, Coal Point Series, Older Débris, Newer Débris.

It has been thought advisable, in consideration of the isolated position of the area and the scanty palæontological data available for comparative purposes, to apply local names to all the series, although in the case of the Coal Point Series identity with beds developed elsewhere is proved.

Mount Camel Series.

Mount Camel and the low hills to the north-west are composed, according to McKay,* of rocks which bear a close resemblance to the supposedly Palæozoic rocks occupying the greater part of the coast-line between Whangaroa and Mangonui. Hector† describes them as a "development of diorites and tufaceous sandstones with mineral impregnations" similar to the series found in several localities further south, and notably in the Puhipuhi area. Where rocks of the series were seen by the writers at the head of Hohoura Harbour, they consist apparently of argillites and grauwackes, and contain veins of barren quartz. The Palæozoic age is doubtful, and it is probable that they are of more recent deposition.

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* Rep. G.S., 1894, p. 72.

† Rep. G.S., 1892, p. lxxxi.

Marshall, who examined the area between Mangonui and Ahipara,[*] maps the older rocks in that area as igneous, whereas McKay[†] considers that both sedimentary and igneous rocks are represented. We think that the older rocks on the coast-line north of Whangaroa Harbour, which Marshall maps as igneous, contain representatives both of sedimentary and igneous rocks. However, in consideration of Marshall's pronounced view, the older rocks between Mangonui and Ahipara are shown as igneous on the map accompanying this paper.

About twelve miles north of Waipapakauri, on the west coast, the prominent hill of Hukatere rises some 300 ft. above the surrounding sandy waste. All outcrops on this hill are at present obscured by a covering of drifted sand, but from its markedly greater elevation it seems probable that it is composed of older rocks possibly of the Mount Camel Series. The outlying pierced island of Matapia may possibly be of the same nature.

On the high land in the immediate neighbourhood of the North Cape headland, according to McKay,[‡] associated with the igneous rocks to be presently described are "slates and sandstones," which he assigns to the same age as the Mount Camel Series.

Whangakea Series.

The rocks which are tentatively placed under this series consist of greenish and purplish indurated stratified rocks, possibly in part argillites, associated with basic and semi-basic igneous rocks, probably both intrusive and contemporaneous. These rocks are either synchronous with or later than the Mount Camel Series.

The Whangakea Series is exposed along the northern coast-line between Cape Maria van Diemen and the western (Whangakea) end of Spirits Bay. At the latter place occur purplish and greyish apparently argillaceous rocks, often much brecciated, and containing rounded lenses of harder material, which give them a conglomeratic appearance. A microscopic examination of these lenses shows that they are largely composed of comminuted fragments of a basic igneous rock whether plutonic or volcanic in origin is not clear. In places definite igneous rocks appear in close association with those just described, though, owing to the intense brecciation, it is difficult to be sure whether they are contemporaneous with or intrusive into the seemingly argillaceous strata. It is probable that the latter are tuffs.

Rocks of even more nondescript character occupy the sea-front from Cape Maria van Diemen to Spirits Bay. The pink-weathering sedimentaries cut by basic plutonics near Kerr Point probably belong to the Whangakea Series.

McKay,[§] on palæontological grounds, considered the rocks of the Whangakea Series to be Triassic. Hector,[||] however, thought that they possibly belonged to the Maitai Series (Lower Carboniferous). We are unable to offer fresh evidence on this important question, beyond saying that the series under discussion bears a fairly close lithological resemblance to certain strata found near Whangaroa Harbour, which we consider may be of late Palæozoic or early Mesozoic age.

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[*] Trans. N.Z. Inst., xl, 1907, p. 82.
[†] Rep. G.S., No. 22, 1894, map facing p. 80.
[‡] Rep. G.S., 1894, p. 89.
[§] Rep. G.S., 1894, p. 90.
[||] Rep. G.S., 1894, p. xix.

This name it is proposed to apply to the series of thin bedded purplish and greenish claystones and well-stratified greyish greensandstones which is exposed in the area under consideration.

The rocks of the Rahia Series outcrop on the shore of Parengarenga Harbour near Yates's house, and again in the low cliffs bordering the harbour towards the mouth of Waitiki Creek, and form the two limbs of an anticline.

At the south end of Rahia Bay the Rahia rocks, consisting of purplish and greenish shales, and well-bedded, greyish greensandstones, in some places containing many plant-remains, have been intruded and baked by igneous rocks, to be presently described, and are unconformably overlain by the gravels of the Older Débris. A little north of this outcrop the rocks are seen in their unaltered state; but farther north still, in Taupiri Bay, they are again associated with igneous rocks.

No clear evidence of the geological age of the Rahia Series has yet been adduced, but Hector* considers it to be Cretaceo-tertiary. Certainly the members of this series bear a considerable lithological resemblance to certain facies of a series near Whangaroa, to which a late Mesozoic or early Tertiary age has been assigned both by McKay† and ourselves.

Coal Point Series.

We would tentatively apply this name to a series of sedimentary and pyroclastic rocks which, beginning in the hills north of Te Kao Settlement, forms a semicircular belt touching the north coast at Spirits Bay, and having a considerable exposure on the east coast near Coal Point.

(1.) *Lower Beds.*—The lowest beds of the Coal Point Series are impure carbonaceous greensandstones, mudstones, and grits, with molluscan and plant remains, fragments of andesitic rock, and thin inconstant coaly partings. These beds are exposed at the north head of Parengarenga Harbour, and it is probable that within the last sixty or seventy years they were also to be seen at the south head of Parengarenga Harbour, where they have since been covered by the advancing sands.

In places the carbonaceous sandstones and grits contain irregular lenses of lignite. At the time of our visit the best outcrops of the "coal" were said to be covered by drifted sand. Those seen were too poor in quality and limited in quantity to be of any commercial value.

Hector‡ gives the following analysis of the lignite:—

Fixed carbon	41·65
Hydrocarbon	18·11
Water	30·03
Ash	10·21
	100·00

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* Rep. G.S., 1894, pp. xvi and 86.

† Rep. G.S., 1894, p. 86.

‡ Rep. G.S., 1894, p. xvii.

A very similar grit-bed occurs at the north end of Wharekau Bay, unconformably overlying the mass of igneous and sedimentary rocks which constitutes the North Cape headland.

(2.) *Upper Beds.* Between Parengarenga North Head and Wharekau Bay the Coal Point Series forms a syncline, the upper beds being exposed along the coast-line. These beds, which are coarse volcanic breccias including fragments of stone up to 2 ft. in diameter, interbedded in their lowest parts with finer sedimentaries, occupy the sea-front as far as Coal Point. They exhibit a rude stratification, and are in some places seamed with calcite veinlets, and in others with stringers of opal.

At Coal Point a seam of impure lignite about 6 chains long and 1 ft. 6 in. thick, striking east and west, and dipping to the south at 35°, is interbedded with the breccias. The outcrop is interesting as affording evidence of the probable presence of a land-surface here during the accumulation of the breccias, but is of no economic importance.

The Coal Point Series throughout the rest of the area in which it occurs is represented only by the breccias which belong to the upper horizon. Good exposures are to be seen on the track from Parengarenga Harbour to Te Paki Sheep station, where pebbles of sedimentary rocks occur amongst the volcanic fragments, and at the eastern point of Spirits Bay. At this latter place "the lower three or four feet" of the breccias "are so crowded with remains of a species of *Scalpellum* as to form an impure shelly limestone."*

(3.) *Petrology.*—Megascopically the constituent fragments of the Coal Point grits and breccias would be identified as andesitic rocks of medium grain, showing phenocrysts of plagioclase and pyroxene. The small fragments from the lower grits are usually more basic in appearance than the boulders of the coarse breccias.

Microscopic sections of the basal grits show that they are composed of fragments of lava closely agreeing with those found in the overlying coarse breccias. In the grit fragments, however, crystals of highly altered olivine are rather frequent. The grits are much seamed with veinlets of a zeolite, apparently natrolite.

Representative sections from the coarse breccias show that the prevalent rock is an augite-andesite, with a hyalopilitic groundmass in which glass predominates over feldspar laths and augite granules. The augite phenocrysts, which vary much in abundance in different sections, are pale brown or yellow in colour. Porphyritic feldspars are abundant, the dominant ones being andesine and labradorite, the latter being the more frequent and having many glass inclusions. (Plate LVI, fig. 1.)

(4.) *Correlation and Age.* The lowest beds of the Coal Point Series contain fossil *Mollusca* which are apparently of Miocene age. McKay† correlates them with the lignite-bearing beds of Cooper's Beach and the fine-grained tuffs at the base of the volcanic breccias of Whangaroa Harbour.

The *Scalpellum* found at the base of the breccias in Spirits Bay is regarded by Hector and McKay as identical with that‡ occurring at Chamberlain's Island, near Auckland, in strata which, it is agreed by Cox,§ Park,||

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* McKay, Rep. G.S., 1894, p. 82.

† Rep. G.S., 1894, pp. 82, 83.

‡ More recently described by Benham as *Pollicipes aucklandicus:* Geol. Mag., March, 1903, p. 110.

§ Rep. G.S., 1879–80, p. 16.

|| Trans. N.Z. Inst., 1889, p. 394.

Mulgan,[*] and Fox,[†] pass conformably up into the Manukau breccias a series of volcanic agglomerates and breccias of extensive development on the west coast north of the Manukau Heads. It is evident, therefore, that the Coal Point Series is to be correlated with the Manukau and Whangaroa breccias and the strata which conformably underlie these breccias. It may be noted that petrologically the component rocks of the Coal Point and Whangaroa breccias show a striking similarity, and that this resemblance seems also to extend to the Manukau breccias and other closely related volcanic beds of the Auckland Isthmus.[‡]

In this connection the two following analyses of general samples—(1) of fragments of Coal Point breccia, (2) of fragments from breccia at St. Paul's, Whangaroa—may be of interest:—

	(1)	(2)
Silica (SiO_2)	59·20	58·20
Alumina (Al_2O_3)	18·03	18·35
Ferric oxide (Fe_2O_3)	1·10	1·11
Ferrous oxide (FeO)	2·88	3·16
Manganous oxide (MnO)	0·10	0·35
Lime (CaO) .. .	7·03	6·20
Magnesia (MgO)	2·51	3·19
Potash (K_2O)	2·28	2·96
Soda (Na_2O)	2·93	2·63
Titanium-dioxide (TiO_2) . ..	1·26	0·87
Carbonic anhydride (CO_2)	Nil	Nil
Water and organic matter .. .	2·08	2·05
	100·00	100·00

Since no unconformity has been recorded between the Coal Point and Rahia Series, it is quite possible that the latter will ultimately prove to be of Miocene age, just as the Waitemata beds, at one time considered to be Cretaceo-tertiary, are now generally admitted to be conformable to the Manukau breccias, and Miocene in age; but further field study will be necessary before any definite opinion can be given on this point.

Older Débris.

Under this heading we propose to place a series of horizontally stratified sands and water-worn gravels that outcrop at various places in the area. The relation of these beds to the Coal Point Series is not clear, but they lie unconformably on the Rahia and older series.

The rocks of the Rahia Series are seen at the southern end of Rahia Bay to be unconformably succeeded by a horizontal layer of fine gravel 6 ft. or 7 ft. thick, followed by 100 ft. or more of horizontal sandstones. In various places throughout the Aupouri Peninsula—as, for instance, on the track from Hukatere to Hohoura—similar beds, horizontally stratified, are seen cropping out of the newer drifting sands. At Scott Point they may be observed filling up the irregularities in the much-dissected older igneous rocks, and forming a flat-topped hill, rising 300 ft. or 400 ft. above sea-level.

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[*] Trans. N.Z. Inst., 1901, p. 429.

[†] Trans. N.Z. Inst., 1901, p. 492.

[‡] See Mulgan and Fox, *loc. cit.*; also Marshall, Trans. N.Z. Inst., xl, 1907, p. 96. Hypersthene, which Marshall finds so widely distributed in the Manukau breccias, is not invariably present in sections of Coal Point breccias.

Inconstant beds of highly carbonised brown or black peat, apparently overlying the uppermost layers of the Older Débris, but possibly unconformable to them, occur in various places, especially at the north end of Rahia Bay. Trunks of trees and roots *in situ* are of frequent occurrence in these deposits, which are too small to be of value as fuel. Kauri-gum is, however, found in fair quantity in and immediately under them.

The firmer scrub-covered country which lies to the east of the ever-advancing west-coast sands, the similar minor accumulations in Spirits Bay, the low sandy flat which separates the North Cape headland from the rest of the high land, and the low flats in the south-east part of Parengarenga Harbour, although doubtless much younger than the stratified beds just described, are also included under this heading. The occurrence of great quantities of kauri-gum and of abundant remains of large trees in the swamps on the land-surface—formed of these beds—points to a protracted period when the land became clothed with a great kauri forest.

Newer Débris.

The most important of the recent deposits are the widespread sand-dunes at present drifting in from the east and west coasts, and the alluvial deposits accumulating in the various swamps and ponds.

Judging from its present rapid rate of advance, the wind-blown sand can only have begun its inroads since the destruction of the kauri forest by the early Maoris. The peculiar topography produced by these drifting sands has already been described. It only remains here to notice the remarkable difference between the east- and west-coast sands. That of the east coast is almost pure silica, and was in former days used for moulding in the ironworks at Onehunga and in the manufacture of glass at Auckland. That of the west coast is of the more ordinary type of quartz and shell sand. Some of the sands near Cape Maria van Diemen and in Spirits Bay consist entirely of finely comminuted shells of great beauty.

*Older Igneous Rocks.**

We propose to subdivide the igneous rocks of the Aupouri Peninsula into an older (or pre-Miocene) and a younger (or Miocene) group. The two series have not been found in contact. The only evidence for this division of the igneous rocks consists in the petrological differences between the two series, and in the much greater degree of alteration of the group regarded as older. The younger group has already been described under the Coal Point Series. The older igneous rocks may belong to one or more distant periods. Some, apparently, are associated with Mount Camel rocks.† Some are found associated with the Whangakea Series, though whether contemporaneous or intrusive is not clear. Others are found intruding and altering Rahia rocks. In other cases they occur unassociated with sedimentaries.

Whether or not, therefore, the whole assemblage is to be regarded as of post-Rahia date must for the present remain uncertain. We propose merely to describe the most important occurrences. Speaking broadly, it may be said that the older igneous rocks are more plutonic in character to the east—*i.e.*, towards North Cape—and more effusive in aspect towards Cape Maria van Diemen and the west coast.

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* In this part we are much indebted to Professor Marshall, who examined the microscope sections and gave us valuable notes on them. For the final results we are, of course, solely responsible.

† Hector, Rep. G.S., 1892, p. lxxxi.

(1.) *Igneous Rocks associated with the Rahia Series.*—The largest occurrence of old volcanic rocks is at Scott Point. In the field this rock shows remarkable spheroidal structure, probably due to movement after partial consolidation of the lava, which gives it a pseudo-agglomeratic appearance. In the more decomposed, clayey material between the harder blocks calcite and chlorite are often developed.

In hand-specimens the rock at Scott Point is a very fine grained, dull-green and reddish rock, containing no identifiable mineral except secondary calcite, which is abundant, both as finely disseminated grains and also as amygdules.

Microscopically, the rock, which is somewhat decomposed, and stained yellow with limonite, appears to be an olivine basalt. The phenocrysts are few, and are feldspar (labradorite chiefly), containing numerous glass inclusions and seldom showing multiple twinning, and olivine with characteristic form but largely altered to calcite. The groundmass is made up of elongated feldspar laths, between which are scattered numerous granules of augite. Professor Marshall notes that the rock resembles the basalt near Ahipara and Takahue described by him in a recent paper.*

Similar igneous rocks occur at Rahia Bay, where, as already stated, they intrude and alter the Rahia Series, and again on the higher sand-shrouded land between Rahia Bay and Cape Maria van Diemen. In this locality, however, it seems doubtful whether or not some of these rocks are contemporaneous flows.

(2.) *Igneous Rocks associated with the Whangakea Series.*—Some doubt exists as to the relationship of the apparently sedimentary rocks to the undoubtedly igneous at Cape Maria van Diemen and at Whangakea. At the latter place there is an extensive development of basalt similar to that occurring at Scott Point, though the olivine crystals are smaller, more numerous, and have been corroded by the action of the unconsolidated magma. Large feldspars are absent, and the small laths show no tendency to arrangement in flow-lines (Plate LVI, fig. 2). A little to the east of Whangakea is seen a coarser igneous rock—possibly a mica-diorite. Darky Hill and the neighbouring high ridges appear to be chiefly composed of a very compact igneous rock in which a finely crystalline structure and small feldspars are visible to the naked eye. Under the microscope this rock proves to be a somewhat altered augite-andesite, in which fairly large, very light brown augites and elongated feldspars (andesine and labradorite) are the only phenocrysts. The groundmass is now obscure, but contains abundant grains of ilmenite, and was apparently made up of feldspar laths and granules of augite and ilmenite imbedded in a glassy base.

(3.) *Igneous Rocks associated with the Mount Camel Series.*—According to McKay,† "intrusive or bedded contemporaneous floes of crystalline rocks—syenite and diorite" occur at the North Cape headland, on the northern coast west of Spirits Bay, and at the head of Parengarenga Harbour. We were able to visit only the first of these localities.

The rock forming the greater part of the North Cape headland is a basic plutonic showing considerable range in structure and in mineralogical composition. On the south the plutonic is overlain by grit-beds of Miocene age, while along its western boundary—near Kerr Point—it has intruded and altered argillaceous rocks which may belong to the Whangakea Series.

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* Trans. N.Z. Inst., vol. xl, 1907, p. 82.

† Rep. G.S., 1894, p. 90.

The dominant types of crystalline rock encountered in the North Cape promontory are norites and gabbros, passing at places into hartzbergites and lherzolites.

In hand-specimens the gabbros and norites vary in texture from coarse to rather fine. The most coarsely grained rock is a norite obtained near Kerr Point, made up of very conspicuous crystals of enstatite, ¼ in. and more in length, apparently imbedded in a crystalline mass of feldspar. A somewhat finer and more even grained rock is the gabbro from North Cape, hand-specimens of which show dark-green augites and white and occasionally pinkish feldspars fairly evenly distributed. A much finer gabbro occurring in the cliffs east of Tom Bowling's Bay, in hand-specimens can only be described as a brownish rock consisting of a fine-grained mixture of rather clear feldspar and somewhat decomposed ferro-magnesian minerals.

Under the microscope the plutonics are seen to be holocrystalline. The feldspars range from labradorite to anorthite, and are usually fresh. In the gabbros the ferro-magnesian mineral is a light-brown pyroxene, seldom showing the diallage structure to any marked extent, and often partially altered to bluish-green hornblende or to uralite. Very much altered olivine is occasionally found. In the norites the hypersthene occasionally is seen to be partially altered into brown or bluish green hornblende (Plate LVI, fig. 3). In the case of the very coarse rock from Kerr Point, bastite has partly taken the place of enstatite.

The hartzbergite which is found near Kerr Point is in hand specimens a pale olive-green rock much flecked with white. It is crossed by a number of fine cracks, along which alteration-products have accumulated. The phenocrysts are large pyroxenes, the greater part of each being dull and earthy, but the cores having a metallic lustre. Microscopic sections show that the rock is made up mainly of serpentinised olivine, which surrounds numerous crystals of enstatite now nearly completely altered to bastite. A considerable quantity of chromite and magnetite occurs in the serpentinised olivine. This rock shows a general resemblance to the hartzbergite from Milford Sound, of which Professor Marshall has kindly lent us sections. The North Cape rock is, however, much more decomposed than that from Milford Sound. Lherzolite has been recognised in bands traversing the gabbro at North Cape. Megascopically the rock is coal-black, finely crystalline, and traversed by irregular streaks of white, which are probably decomposition-products. Under the microscope the lherzolite proves to be composed mainly of olivine, much of which is converted into serpentine. Some enstatite, diallage, and brown hornblende also occur. This rock, on the whole, shows a closer resemblance to the hartzbergite from Milford Sound than to the lherzolite from Cow Saddle, to the north-east of Milford Sound.* Nevertheless, the presence of diallage seems to place it amongst the lherzolites (Plate LVII, fig. 1). Cutting the lherzolite at North Cape are several clearly defined bands, 1 ft. or more in thickness, of a dull green homogeneous-looking rock, with a hardness of about 6. Microscopic examination shows this rock to be a very fine grained aggregate of diopside and sphene, with a little feldspar (Plate LVII, fig. 2).

The occurrence of ultra-basic rocks closely allied to those found near Milford Sound and elsewhere in the South Island is of great interest. The foregoing notes, unaccompanied as they are by chemical analyses, must be regarded as of a purely preliminary character.

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* Marshall, Trans. N.Z. Inst., 1904, p. 483. (See Marshall, Trans. N.Z. Inst., 1905, p. 564.)

(4.) *Economic Deposits in the Older Igneous Rocks.* A few veins of rusty calcite and of quartz pseudomorphic after pyrite were noted in igneous rocks near Kerr Point. An assay of a sample from these veins yielded

Gold ..	1 dwt. 21 gr.	Value per ton ..	7s. 6d.
Silver ..	0 „ 15 „		

In the same locality bands rich in pyrite and containing some chalcopyrite also occur. These were examined for gold, silver, copper, cobalt, and nickel, but yielded only—

Silver	7 dwt. 13 gr. per ton.
Copper	6·21 per cent.

The surface of the high land forming the North Cape Promontory is strewn with blocks of hydrous ferric oxide derived from the decomposition of the underlying basic rocks. An analysis of this is subjoined, which is interesting as showing the high percentage of chromic oxide probably derived from the chromite of the ultra-basic rocks: -

Silica (SiO_2)	2·80
Alumina (Al_2O_3)	7·69
Ferric oxide* (Fe_2O_3)	69·07
Manganous oxide (MnO)	0·10
Lime (CaO)	Nil
Magnesia (MgO)	0·60
Chromic oxide (Cr_2O_3)	3·25
Loss on ignition	16·01
Undetermined	0·39
	100·00

* Equivalent to metallic iron 48·35 per cent.

Dr. Maclaurin the Dominion Analyst, adds the following note: "On heating, the sample gives a colour similar to that of Parapara iron-ore when burnt, and therefore should be suitable for paint."

EXPLANATION OF PLATES LII–LVII.

Plate LII.

Map of the northernmost portion of New Zealand.

Plate LIII.

Fig. 1. Sand-dunes on sea-coast near Te Paki.
Fig. 2. "Bad Lands" topography, Rahia Bay.

Plate LIV.

Fig. 1. Spirits Bay, from Whangakea end.
Fig. 2. Rock bench at Cape Maria van Diemen.

Plate LV.

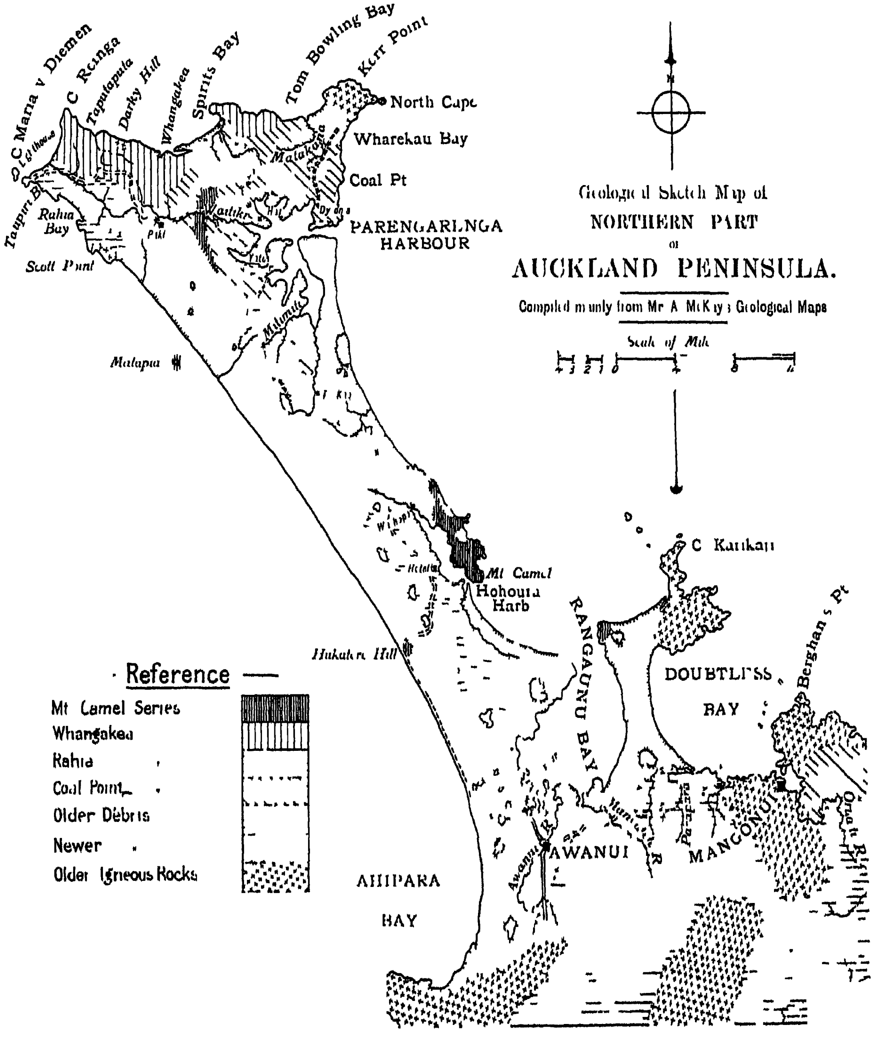
Fig. 1. Boundary between sand-dunes and Older Débris near Te Paki. Shows ponds formed by clogging action of advancing sand.
Fig. 2. Advancing sand near Cape Maria van Diemen. The scrub-covered hill is an outcrop of the Older Débris nearly overwhelmed by the sand.

Plate LVI.

Fig. 1. Andesite breccia from near Coal Point.
Fig. 2. Basalt from Whangakea, west end of Spirits Bay.
Fig. 3. Norite from north end of Wharekau Bay.

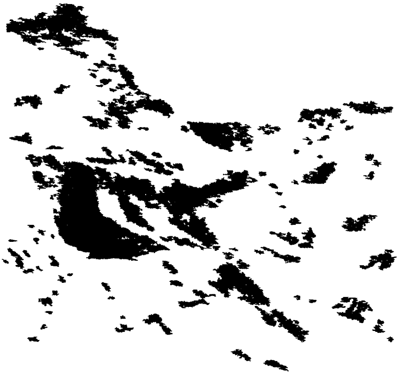
Plate LVII.

Fig. 1. Lherzolite from mainland just inside North Cape Island.
Fig. 2. Diopside-sphene band cutting the rock shown in fig. 1.



MAP OF NORTHERNMOST NEW ZEALAND.—Bell and Clarke.

1



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GEOLOGY OF NORTHERNMOST NEW ZEALAND.—BELL AND CLARKE

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GEOLOGY OF NORTHERNMOST NEW ZEALAND.—BELL AND CLARKE

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GEOLOGY OF NORTHERNMOST NEW ZEALAND.—Bell and Clarke.

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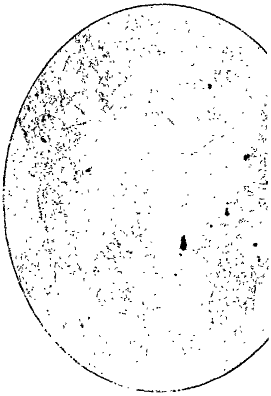

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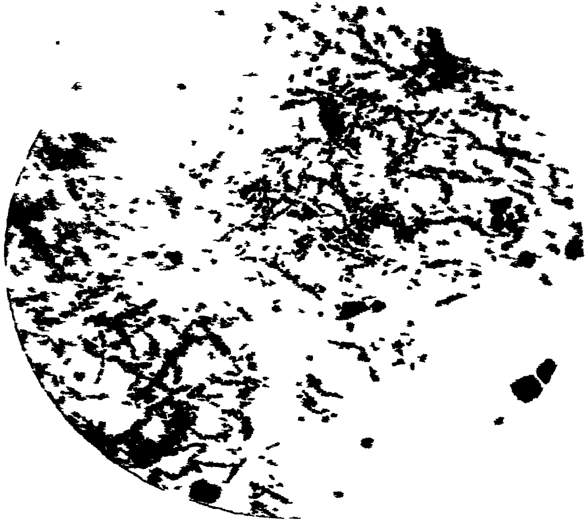
GEOLOGY OF NORTHERNMOST NEW ZEALAND.—Bell and Clarke.



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GEOLOGY OF NORTHERNMOST NEW ZEALAND —Bell and Clarke

ART. LXIII.—*Maori Numeration: Being a Reply to Mr. Elsdon Best's Paper on "Maori Numeration" in Trans. N.Z. Inst., Vol. xxxix.*

By HARE HONGI.

Communicated by A. Hamilton.

[Read before the Wellington Philosophical Society, 1st September, 1909.]

IN view of the splendid contributions to science which this Institute has from time to time published in its Transactions and Proceedings, many of which I have read, I have very much pleasure indeed, and no little diffidence, in submitting for consideration an essay of a somewhat critical nature on the subject of Maori numeration. Whilst, however, conceding that many subjects discussed by the Institute are necessarily of a controversial character—that of the moa-bird, for instance, no living specimens of which have been accessible to students—I should like to make my present position quite clear by stating at the outset that there is no important subject in which I myself am interested so little open to controversial and argumentative discussion as that of Maori numeration. Looking back through the century of years just closed, we see its ample field crowded with living Native specimens, with wise men having a just knowledge of this particular subject, and a knowledge which has been readily imparted to the inquirer. Not only so, but the Maori is a keen, an eager debater and controversialist: some of his finest literary remains are found to-day in what are known as "disputation songs"—*i.e.*, *waiata tautohetohe*, or *waiata tautitotito*. A great advocate for "correct forms," one of the readiest phrases which fell from the lips of the elders was "*Kia tika*," or "Be exact." And so, although disputes have been waged abroad on a thousand-and-one subjects of historical uncertainty and interest—such as that of descent, ancestry, traditional canoes, the introduction of the *kumara* tuber, causes of intertribal warfare, women, lands, and even to so minute a question as the interpretation of an historical passage or the primary meaning of a certain historical term—no marked disputation concerning either principle or detail of the system of numeration as regularly taught and practised by him has been recorded. The inference is obvious. The Maori system of numeration as generally known is at once so methodical in its arrangements, so well defined in its parts, and so comprehensive in its form that apparently no sufficient ground for disputation has presented itself.

These preliminary observations are suggested by the recent perusal of an article on Maori numeration, by Mr. Elsdon Best, which appears in the Transactions of this Institute (vol. xxxix, p. 150). Mr. Best has been long and very favourably known as a sturdy contributor to the pages of Maori literature, and containing, as his productions usually do, a large proportion of purely Native material, he has placed on record a quantity of most interesting, useful, and highly informing original Native matter. In the voluminous article under notice, however, it is strikingly apparent that Mr. Best has deviated widely from his usual course. The Native originals which he presents are comparatively few, and those few unimportant and misleading. He wanders far outside the area of Maori research, and, as a consequence, he appears to have done himself and his subject alike a very grave injustice. In the weakness of his authorities, in the enlarging of his field, and in labouring to prove that which is not possible, Mr. Best exhibits a peculiarly capricious estimate of the whole subject. He has, in short, so clouded the outlook of otherwise clear premises that, in the name and interests of truth, I venture this protest.

In the course of submitting the following numerical tables illustrative of the original system of Maori numeration, I propose to demonstrate that Mr. Best's observations on (*a*) the numeral prefix are entirely inadequate, and that those on (*b*) the term *ngahuru* and (*c*) the term *tekau* require considerable modification.

(*a*.) THE NUMERAL PREFIX.

Mr. Best states, "To the above terms [*tahi*, *rua*, *toru*, &c.] various prefixes are applied. When using any of these expressions for numbers in conversation, or when enumerating articles, the term *ko* is prefixed to the first, which thus becomes *kotahi*. From two to nine inclusive the prefix is *e*. To *ngahuru* no prefix is applied as a cardinal, but as an ordinal *tua* is so employed: *tua-ngahuru* = tenth. *Tekau*, the modern term for ten, never bears a prefix, the ordinal being expressed by the use of the definite article: *te tekau* = the tenth. Thus we have the cardinal numbers as follows:—

"Ko-tahi	=	one	E-ono	=	six
E-rua	=	two	E-whitu	=	seven
E-toru	=	three	E-waru	=	eight
E-wha	=	four	E-iwa	=	nine
E-rima	=	five	Ngahuru, *or* tekau	=	ten

as used in Maori. These terms are often used when counting. But an ancient and more correct style of actual enumeration is by prefixing *ka* to the numerals. Probably, however, *ka* is not a true prefix in this case: for my own part, I do not so regard it," &c.

That extract in itself justifies my statement that the writer held a very capricious estimate of the special knowledge peculiarly required in this particular matter. In the first place, *kotahi* means single and alone rather than one of a series—as, one, two, three. We may speak of *kotahi*, a single one; of *kotahi tekau*, a single ten; of *kotahi rau*, a single hundred; and of *kotahi mano*, a single thousand: but not of *kotahi* as a first one, as a precursor to some following number. For that very reason, *kotahi* is not used by competent speakers where such a thing as progressive numeration follows. The prefix *e* of his example is derived, as I shall presently show, from a different source altogether. The numeral prefix *e*, which speaks in the plural sense, is derived from *he*, which speaks in the singular sense. Thus: *He-tahi*, *e-rua*, *e-toru*, and so on. *Ka*, too, as we shall presently see, is an undoubtedly proper and true numeral prefix. As to numeral prefixes not applying to the terms *ngahuru* and *tekau*, I will presently show that most, if not all, numeral prefixes do properly so apply.

But first I would submit that the Maori language is a scientific language —that it is not a fabric of merely adventitious texture. By way of illustrating this, let us for a moment consider such well-known terms as *arero*, *reo*, *korero* = the tongue, the voice, to speak. To the Maori ear a relationship is set up of these terms by the similitude of sounds and letters. This similitude, I submit, is intentional. Moreover, it is an indisputable fact that the Maori has given a different name to every species of bird, fish, tree, shrub, plant, weed, stone, cloud-formation, colour and tint, cardinal and intermediate wind-point—in short, to the sum total of visible phenomena as known to him—without either repetition or confusion. In the same sense, the various stages of a progressive action, from simple to complex, can be faithfully—need I urge, graphically—described. Could such a state of things exist if his language was crude, inadequate, unscientific ? I think not. In its perspicuity, in its comprehensiveness, I have found the Maori language to be, in its particular domain, absolutely reliable, and free from confusion of sense. Those good qualities, I shall now proceed to show, he has worked into his system of numeration—premising that if I fail to make this clear it is my fault, and not the fault of the system.

The Maori system of numeration was perfected by means of the ancillary prefix. He found five vowels in his language—*a*, *e*, *i*, *o*, and *u*—and those letters he appears to have deliberately employed as aids in the conveying of different senses of numeration which different situations created. By taking these letters seriatim we can learn both of the manner in which he used them and the ends which he had before him. The first vowel, then, is *a* ; this he uses as *ka*. As a numeral prefix *ka* answers the question, " How many does that make ? "

[NOTE.—*Ma* is used as a numeral conjunction signifying " and " ; it serves as a threadle with which to catch up the successive units to loop them on to their respective tens. The definite article *te* (the), its plural *nga* (the), and the indefinite article *he* (plurally *e*) are used as occasion requires.]

TABLE A.

Ka tahi	That makes one	= 1
Ka rua	„ two	2
Ka toru	„ three	3
Ka wha	„ four	4
Ka rima	„ five	5
Ka ono	„ six	6
Ka whitu	„ seven	7
Ka waru	„ eight	8
Ka iwa	„ nine	9
Ka tahi te tekau	That makes the one ten	10
Ka tekau ma-tahi	„ ten and one	11
Ka tekau ma-rua	„ ten and two	12
Ka tekau ma-toru	„ ten and three	13
Ka tekau ma-wha	„ ten and four	14
Ka tekau ma-rima	„ ten and five	15
Ka tekau ma-ono	„ ten and six	16
Ka tekau ma-whitu	„ ten and seven	17
Ka tekau ma-waru	„ ten and eight	18
Ka tekau ma-iwa	„ ten and nine	19
Ka rua nga tekau	„ the two tens	20
Ka rua tekau ma-tahi	That makes two tens and one	21
Ka rua tekau ma-rua	„ two tens and two	22
Ka rua tekau ma-toru	„ two tens and three	23
Ka rua tekau ma-wha	„ two tens and four	24
Ka rua tekau ma-rima	„ two tens and five	25
Ka rua tekau ma-ono	„ two tens and six	26
Ka rua tekau ma-whitu	„ two tens and seven	27
Ka rua tekau ma-waru	„ two tens and eight	28
Ka rua tekau ma-iwa	„ two tens and nine	29
Ka toru nga tekau	„ the three tens	30
Ka toru tekau ma-tahi	„ three tens and one	31*
Ka toru tekau ma-iwa	„ three tens and nine	39
Ka wha nga tekau	„ the four tens	40
Ka wha tekau ma-tahi	„ four tens and one	41
Ka wha tekau ma-iwa	„ four tens and nine	49

---

* And so on, adding successive units, to 38. To save space, in each case only the first unit and the last unit are given.

TABLE A—*continued.*

Ka rima nga tekau	That makes the five tens	=50
Ka rima tekau ma-tahi	,, five tens and one	51
Ka rima tekau ma-iwa	,, five tens and nine	59
Ka ono nga tekau	,, the six tens	60
Ka ono tekau ma-tahi	,, six tens and one	61
Ka ono tekau ma-iwa	,, six tens and nine	69
Ka whitu nga tekau	,, the seven tens	70
Ka whitu tekau ma-tahi	,, seven tens and one	71
Ka whitu tekau ma-iwa	,, seven tens and nine	79
Ka waru nga tekau	,, the eight tens	80
Ka waru tekau ma-tahi	,, eight tens and one	81
Ka waru tekau ma-iwa	,, eight tens and nine	89
Ka iwa nga tekau	,, the nine tens	90
Ka iwa tekau ma-tahi	,, nine tens and one	91
Ka iwa tekau ma-iwa	,, nine tens and nine	99
Ka kotahi te rau	,, the one hundred	100
Ka kotahi te rau ma-tahi	That makes the one hundred and one	101
Ka kotahi te rau ma-iwa	,, one hundred and nine	109
Ka kotahi te rau, ka kotahi te tekau	That makes the one hundred and the one ten	110
Ka rau, ka kotahi te tekau ma-tahi	,, one hundred, one ten, and one	111
Ka rau, ka kotahi tekau ma-iwa	,, one hundred, ten, and nine	119
Ka kotahi te rau. ka rua nga tekau	,, the one hundred and the two tens	120

So the process goes on, by simply linking up the units to the tens and the tens to the hundreds, until a thousand is reached. I will now, therefore, merely set up the hundreds :—

Ka rua nga rau	That makes the two hundreds	= 200
Ka toru nga rau	,, three hundreds	300
Ka wha nga rau	,, four hundreds	400
Ka rima nga rau	,, five hundreds	500
Ka ono nga rau	,, six hundreds	600
Ka whitu nga rau	,, seven hundreds	700
Ka waru nga rau	,, eight hundreds	800
Ka iwa nga rau	,, nine hundreds	900
Ka iwa nga rau, ka iwa nga tekau ma-iwa	That makes the nine hundreds, nine tens, and nine	999
Ka kotahi te mano	That makes the one thousand	1,000
Ka mano	,, a thousand.	
Ka mano tini	,, innumerable thousands.	
Ka mano tuarea	,, a thousand thousands.	
Ka mano tini whaioio	,, countless thousands.	
Ka ngea, ka ngea, ka ngea	,, an inconceivable number.	

In that method the uses of the numeral prefix *ka* are fully shown. It will be observed that after a hundred is reached *ka* is used both before the hundred and before its accompanying ten. The articles are used in a precisely similar way, on the principle that an article must appear before each substantive in a sentence—as, Te *waka me* nga *hoe* = *the* canoe and *the* paddles.

It is interesting to note that the Natives of Easter Island use identically the same *ka* numeral prefix method, including its repetition in a single sentence, and its process from the lowest number — *ka-tahi* = one — to the very highest, in a table of progressive numeration. The dialect of this branch of the race appears to approach Maori very closely—much more so than that of any other branch. In a publication issued by the United States Government, entitled "Report of National Museum, 1889," specimens of this dialect are given, and its concluding page contains a table of numerals which is of the first importance to this inquiry. There is but one table set out, and it progresses step by step. From that table I submit the following extracts :—

1. Ka-tahi.
11. Ka-tahi te angahuru, ka-tahi. (Note the repeated *ka.*)
100. Ka rau.
101. Ka tahi te rau ma-tahi. (Note the *ma-tahi.*)
200. Ka rua te rau. (Note the peculiar use of the singular article.)
201. Ka rua te rau ma-tahi.
300. Ka toru te rau.
301. Ka toru te rau ma-tahi.
400. Ka ha te rau.

And so on.

In comparing this with our Table A, internal differences are readily observed. For instance, the use of the article singular for both the singular and the plural—*ka tahi* te *rau,* and *Ka rua* te *rau.* The repeated *ka,* too, is used to usurp the place of *ma*—*ma,* it appears, not being used until a hundred is reached—*ka tahi te rau* ma *tahi*—whereas with the Maori it is after a hundred is reached that the *ka* is repeated. Obviously their *ma-tahi* means " and one," just as it does with us, and it is as proper to their " ten and one " as it is to their " hundred and one," in which it first appears. That, however, and the misuse of the singular article *te* in connection with the plural number—*ka toru* te *rau* = the three hundreds—may be entirely due to the compilers of their table. It is in nice matters that special knowledge on the part of the compiler is very much needed ; the pity of it is that such knowledge is too rare. However, as the table stands, and notwithstanding its apparent defects, it is a fine (because independent) example of this particular method of Maori numeration. Under " *Ngahuru,*" we shall have occasion to further notice it.

Let us now, and more briefly, consider the uses of the next vowel, *e. E* speaks in a plural sense ; in a singular sense it is used as *he.* As a numerical prefix, *e* or *he* answers the question, " How many is (or are) there ? "

TABLE B.

He tahi ..	There is one	= 1
E rua ..	There are two	2
E toru ..	„ three	3
E wha	„ four	4
E rima	„ five	5
E ono	„ six	6
E whitu	„ seven	7
E waru	„ eight	8
E iwa	„ nine	9
He tekau	There is ten	10
He tekau ma-tahi	There is ten and one	11
He tekau ma-rua ..	„ ten and two	12
He tekau ma-toru..	„ ten and three	13
He tekau ma-wha	„ ten and four	14
He tekau ma-rima	„ ten and five	15
He tekau ma-ono ..	„ ten and six	16
He tekau ma-whitu	„ ten and seven	17
He tekau ma-waru	„ ten and eight	18
He tekau ma-iwa ..	„ ten and nine	19
E rua nga tekau ..	There are the two tens	20
E rua tekau ma-tahi	„ two tens and one	21
E rua tekau ma-iwa	„ two tens and nine	29
E toru nga tekau ..	„ the three tens	30
E toru tekau ma-iwa	„ three tens and nine	39
E wha nga tekau ..	„ the four tens	40

TABLE B—*continued.*

E wha tekau ma-iwa	There are four tens and nine	=49
E rima nga tekau	,, the five tens	50
E rima tekau ma-iwa	,, five tens and nine	59
E ono nga tekau	,, the six tens	60
E ono tekau ma-iwa	,, six tens and nine	69
E whitu nga tekau	,, the seven tens	70
E whitu tekau ma-iwa	,, seven tens and nine	79
E waru nga tekau	,, the eight tens	80
E waru tekau ma-iwa	,, eight tens and nine	89
E iwa nga tekau	,, the nine tens	90
E iwa tekau ma-iwa	,, nine tens and nine	99
He rau	There is a hundred	100
He rau me te tahi	,, a hundred with one added	101
He rau me te tekau	,, a hundred with ten added	110
He rau, he tekau, ma-tahi	,, a hundred, a ten, and one	111
He rau, e rua nga tekau	,, a hundred with the two tens added	120
E rua nga rau	There are the two hundreds	200
E toru nga rau	,, three hundreds	300
E wha nga rau	,, four hundreds	400
E rima nga rau	,, five hundreds	500
E ono nga rau	,, six hundreds	600
E whitu nga rau	,, seven hundreds	700
E waru nga rau	,, eight hundreds	800
E iwa nga rau	,, nine hundreds	900
E iwa nga rau, e iwa nga tekau, ma-iwa	,, nine hundreds, nine tens, and nine	999
He mano	There is a thousand	1,000
He mano tini	,, innumerable.	
He mano tuarea	,, a thousand thousands.	
He mano tini whaioio	,, a countless number of thousands.	
He ngea, he ngea, he ngea	,, an inconceivable number—myriads.	

Observe that the numeral prefix is indispensable throughout.

Hei, as a numeral prefix, answers the question, " How many times does this make ? "

Hei tahi	One.	Hei rima	Five.
Hei rua	Two.	Hei tekau	Ten.
Hei toru	Three.	Hei rau	A hundred.
Hei wha	Four.	Hei mano	A thousand.

We now proceed to consider the uses of the next vowel, *i*. This vowel is used in the term *kia*. As a numeral prefix, *kia* answers such questions as, " How many will you have ? " " How many are there to be ? "

TABLE C.

Kia tahi	Let there be one	= 1
Kia rua	,, two	2
Kia toru	,, three	3
Kia wha	,, four	4
Kia rima	,, five	5
Kia ono	,, six	6
Kia whitu	,, seven	7
Kia waru	,, eight	8
Kia iwa	,, nine	9
Kia tekau	,, ten	10
Kia tekau ma-tahi	,, ten and one	11
Kia rua nga tekau	,, the two tens	20
Kia toru nga tekau	,, the three tens	30
Kia wha nga tekau	,, the four tens	40
Kia rima nga tekau	,, the five tens	50
Kia ono nga tekau	,, the six tens	60
Kia whitu nga tekau	,, the seven tens	70

TABLE C—*continued.*

Kia waru nga tekau	Let there be eight tens	= 80
Kia iwa nga tekau	,, nine tens	90
Kia kotahi te rau	,, the one hundred	100
Kia rua nga rau	,, the two hundreds	200
Kia toru nga rau	,, the three hundreds	300
Kia wha nga rau	,, the four hundreds	400
Kia rima nga rau	,, the five hundreds	500
Kia ono nga rau	,, the six hundreds	600
Kia whitu nga rau	,, the seven hundreds	700
Kia waru nga rau	,, the eight hundreds	800
Kia iwa nga rau	,, the nine hundreds	900
Kia iwa nga rau, kia iwa nga tekau, ma-iwa	,, the nine hundreds, nine tens, and nine	999
Kia kotahi te mano	,, the one thousand	1,000
Kia mano tini	,, thousands innumerable.	
Kia kotahi te mano tuarea	,, one thousand thousands.	
Kia mano tini whaioio	,, countless thousands.	
Kia ngea, kia ngea, kia ngea	,, inconceivable—myriads.	

The next vowel whose processes we may consider is *o*. As a numeral prefix, *o* appears in *ko*, *toko*, and *hoko*. In each case it speaks exclusively of persons, of personal doings, and of personal possessions. In progressive numeration *ko* is used with an article, giving to its numeral the sense of an ordinal of the personal element.

TABLE D.

Ko te tahi	'Tis the first.
Ko te rua	,, second.
Ko te toru	,, third.
Ko te wha	,, fourth.
Ko te rima	,, fifth.
Ko te ono	,, sixth.
Ko te whitu	,, seventh.
Ko te waru	,, eighth.
Ko te iwa	,, ninth.
Ko te tekau	,, tenth.
Ko te tekau ma-tahi	,, eleventh.
Ko te tekau ma-rua	,, twelfth.
Ko te rua tekau	,, twentieth (singular article).
Ko te toru tekau	,, thirtieth.
Ko te wha tekau	,, fortieth.
Ko te rima tekau	,, fiftieth.
Ko te ono tekau	,, sixtieth.
Ko te whitu tekau	,, seventieth.
Ko te waru tekau	,, eightieth.
Ko te iwa tekau	,, nintieth.
Ko te iwa tekau ma-iwa	,, ninety-ninth.
Ko te tahi o nga rau	,, first of the hundreds.
Ko te rua o nga rau	,, two hundredth.
Ko te toru o nga rau	,, three hundredth.
Ko te mano	,, thousandth.

In proceeding to discuss the allied prefixes *toko* and *hoko* it is necessary to bear in mind that we are considering various clearly defined methods of progressive numeration. Those who have read the article under notice, by Mr. Best, are doubtless aware that he himself had this object in view. Now, on page 152 Mr. Best sets out a table in which the numeral prefix *toko* substantially operates. In that table unity of method is completely destroyed by the intrusion of the initial term *kotahi* and the final term *tekau*, neither of which is proper to it. Apparently in justification of the *kotahi*, Mr. Best writes, " During a residence of eleven years' duration among the Tuhoe

Tribe, once only have I heard *toko* prefixed to *tahi*." Premising that a typical instance of the use of *toko-tahi* is to be found in Grey's "Polynesian Mythology" (page 51), it is a rule in good Maori speech that an answer to a question conforms verbally to the question itself. A few examples will illustrate this rule :—

1. Ko whea koe ? Ko Hokianga Au. (Ko—Ko.)
2. Kei hea tena whenua ? Kei raro. (Kei—Kei.)
3. E haere ana koe ko te aha ? E haere ana Au ko te toro i aku whanaunga. (E haere ana ko—E haere ana ko.)
4. A hea koe hoki mai ai ? A te Marama ki tua nei. (A—A.)
5. Toko-hia o hoa haere ? Toko-tahi tonu. (Toko—Toko.)

And so on.

That rule holds good in numeration. Thus, when the question is—

Ka hia ?	*Answer,*	Ka tahi.
E hia ?	,,	E rua.
Kia hia ?	,,	Kia wha.
Ko te hia ?	,,	Ko te rima.
Toko-hia ?	,,	Toko-tahi.

In the answer the number is, of course, regulated by its fact. All of which should be too obvious to require lengthy explanation. *Toko-tahi* is therefore proper to the *toko* table. *Tekau*, however, is not proper to the table, because (*a*) we are treating of numeral prefixes, and (*b*) without a prefix *tekau* conveys no particular sense. Mr. Best was confronted with the peculiarity that *toko-tekau* is not used; it is at that point that *hoko*, a multiple of ten, carries forward this method of numeration. Therefore, *hoko-tahi* = one ten, *or* ten times one (persons). The following is the regular form of the *toko* (and its allied term, *hoko*) table :—

Toko-tahi ..	.. one person	= 1	Hoko-tahi ..	.. One ten	= 10
Toko-rua ..	.. two persons	2	Hoko-rua ..	.. Two tens	20
Toko-toru ..	.. three ,,	3	Hoko-toru ..	.. Three tens	30
Toko-wha ..	.. four ,,	4	Hoko-wha ..	.. Four tens	40
Toko-rima ..	.. five ,,	5	Hoko-rima ..	.. Five tens	50
Toko-ono ..	.. six ,,	6	Hoko-ono ..	.. Six tens	60
Toko-whitu..	.. seven ,,	7	Hoko-whitu..	.. Seven tens	70
Toko-waru ..	.. eight		Hoko-waru ..	.. Eight tens	80
Toko-iwa ..	.. nine		Hoko-iwa ..	.. Nine tens	90

Here the method ends, for, as *toko* finishes with the ninth unit, so *hoko* finishes at the ninth ten. But *hoko* proceeds to higher numbers with the aid of a suffix—the suffix *topu*, the literal meaning of which is "to double." In setting out this table of higher numeration, it serves the purposes of clarity by proceeding from the simple to the complex, thus (prefix as sense requires) :—

Tahi-pu ..	Twice	one	= 2
Rua-pu ..	,,	two	4
Toru-pu ..	,,	three	6
Wha-pu ..	,,	four	8
Rima-pu	,,	five	10
Ono-pu ..	,,	six	12
Whitu-pu	,,	seven	14
Waru-pu	,,	eight	16
Iwa-pu ..	,,	nine	18
Tekau topu	,,	ten	20
Rua tekau topu ..	,,	twenty	40
Toru tekau topu ..	,,	thirty	60

Wha tekau topu	Twice forty	= 80
Rima tekau topu	,, fifty	100
Ono tekau topu	,, sixty	120
Whitu tekau topu	,, seventy	140
Waru tekau topu	,, eighty	160
Iwa tekau topu	,, ninety	180
Kotahi rau topu	,, one hundred	200
Rua rau topu	,, two hundred	400
Toru rau topu	,, three hundred	600
Wha rau topu	,, four hundred	800
Rima rau topu	,, five hundred	1,000
Kotahi mano topu	,, one thousand	2,000

(Higher numbers as required. When absolute exactness is required, an odd one is referred to as *tai-tahi* or *tau-tahi.*)

Strictly of persons :—

Hoko-tahi topu	Ten ones doubled	= 20
Hoko-rua topu	Ten twos doubled	40
Hoko-toru topu	Ten threes doubled	60
Hoko-wha topu	Ten fours doubled	80
Hoko-rima topu	Ten fives doubled	100
Hoko-ono topu	Ten sixes doubled	120
Hoko-whitu topu	Ten sevens doubled	140
Hoko-waru topu	Ten eights doubled	160
Hoko-iwa topu	Ten nines doubled	180
He rua rau tangata tonu	A number of two hundred men	200
He rua rau me te hoko-tahi	Two hundred and one ten	210
He rua rau me te hoko-rua	Two hundred and two tens	220

So the process may be continued to any known number. Quoting Maunsell's "Maori Grammar," Mr. Best notes, "The Maori mode of counting has always heretofore been by pairs: thus *hoko-rua,* twenty, stands for twenty pair—*i.e.,* forty—and so on. When they wish it to be understood singly they postfix *takitaki* to the numeral adjective—*i.e., hoko-rua takitaki* = twenty." The extraordinary statement that the Maori mode of counting has "always heretofore been by pairs" is absolutely beneath notice. Of a dozen or so distinct modes, one only is by means of doubling, and this mode Mr. Maunsell miscalls "by pairs." A counting by pairs is described as a *tatau-a-takirua*—literally, a counting two by two. The term *topu,* or *pu,* has no use in that connection, but is used for lots, bundles, parcels, and so forth, without reference to the number which each might contain. As to *hokorua takitahi,* such a phrase is proper in a case of misunderstanding. A speaker may be asked, "Are you speaking of twenty doubled (*hoko-rua pu*) ?" and he may answer, "Oh, no; I am speaking of twenty singly (*hoko-rua taki-tahi*)." Beyond this the phrase has no peculiar significance.

Taki is a numeral prefix, and as such answers the question, "How were the numbers made up ?"—

Taki-tahi	By ones.	Taki-waru	By eights.
Taki-rua	twos.	Taki-iwa	nines.
Taki-toru	threes.	Taki-tekau	tens.
Taki-wha	, fours.	Taki-rua tekau	twenties.
Taki-rima	, fives.	Taki toru tekau	thirties.
Taki-ono	, sixes.	Taki rau	hundreds.
Taki-whitu	, sevens.	Taki mano	thousands.

We now reach the final vowel of our series, which is *u.* As we have seen, it occurs in the suffix *pu.* It also occurs in the ordinal prefix *tua,* a prefix which answers the question as to the order in which a person or thing stands :—

TABLE E.

Tua-tahi	First.	Tua-waru	Eighth.
Tua-rua	Second.	Tua-iwa	Ninth.
Tua-toru	Third.	Tua tekau	Tenth.
Tua-wha	Fourth.	Tua rua tekau	Twentieth.
Tua-rima	Fifth.	Tua toru tekau	Thirtieth.
Tua-ono	Sixth.	Tua rau	Hundredth.
Tua-whitu	Seventh.	Tua mano	Thousandth.

Having thus far, with more or less detail, set out the various numeral prefixes used by the Maori in these original modes of numeration, and having also demonstrated an apparently systematic adoption of the five vowels in the original arrangement of those prefixes, as in Tables A, B, C, D, and E, I now pass on to other considerations. The functions of the various numeral prefixes have been clearly shown, without burdening the tables with minor and, after all, inconsequential detail. In the methods before him, the student is provided with the material on the lines of which he may extend the process, by detail, to its limits.

I have not followed Mr. Best along his many prospecting by-paths ; to do so would be alike tedious and unprofitable. To give one instance (page 159) : “ It appears to me that at some period of their history the Maori must have used a vigesimal numerical method—a system of counting by scores, or twenties. I shall include in this paper a table showing the method so far as I have been able to ascertain it from my local Native friends. It will be observed that there was a special term (*tekau*) for twenty, but none for thirty ; a special term (*hokorua*) for forty, but none for fifty ; a special term (*hokotoru*) for sixty, but none for seventy ; and so on.” All of which is to say that “ ten ” meant twenty, that “ twenty ” meant forty, and that “ thirty ” meant sixty, without the aid of the necessary word “ to double ” (*topu*), making ten twice ten, and so on. Such a proposition makes for the confounding of the whole of a well-ordered system, and reason refuses to discuss it. If there is a distinct method of counting by scores, or *tatau-a-rua tekau*, other than—

Hoko-tahi pu	Ten doubled	= 20
Hoko-rua pu	Twenty doubled	40
Hoko-toru pu	Thirty doubled	60

by all means let us know of it ; but pray do not attach a double force to terms the values of which are known and fixed. Why not—

Hoko-rua	Twenty
Hoko-wha	Forty
Hoko-ono	Sixty

in which the meanings of the terms are not strained ? But let us pass on.

(*b.*) THE TERM “ NGAHURU.”

It is not too much to claim that the Maori said what he meant, and meant what he said. To put this in another way, it is a rule that a Maori word, or a term, has a certain well-defined primary meaning. The accepted primary meaning of the term *ngahuru* is “ the fulness, the abundance,” as is more fully set out in the extended form—*nga-huru kai paenga* = the fulness, the abundance of food ; therefore, “ harvest-time, the harvest month.”

The harvest month is the month of March (the Maori year commences in June), which is the tenth month of the Maori year. *Nga-huru*, therefore, has become the name for and commonly indicates the tenth month, and from this fact it apparently derives that secondary meaning of tenth which is commonly used in rituals of thanks-offering to the gods, in religious subjects generally, and especially in matters bearing upon food-crops. The term *nga-huru*, then, is used for the tenth month, for a tenth portion of food, for the tenth heaven, and so on. It is to be found in the rituals to Tane, as lord of the year; to Rongo, as lord of the harvest; also to the divinity Tawhaki. That explanation is intended to illustrate that the term *nga-huru* is semi-religious in its functions, that its use is special and restricted, and that it is not applied to ordinary numeration by those who understand its true mission.

The following original Maori terms for the four seasons of the year—*Ao o te tau, Wa o te tau*—show the true place and meaning of *nga-huru* :—

Hotoke or *makariri* = piercing colds—winter.
Ma-huru or *koanga* = returning warmth, digging-time—spring.
Raumati = leaf-crumpler, water-evaporator—summer.
Nga-huru = fulness of abundance, harvest-time—autumn.
Takurua = midwinter.
Rehua = midsummer.

Each separate month (*marama*) has also its characteristic name. I present one set, which is useful to the purposes of this inquiry. The *Tamatea* here (lit., "Bright son") speaks of the sun itself; the *tu* (lit., "to stand") speaks of the change of position which the sun monthly takes up in his annual progress :—

Tamatea tu tahi	.. Tamatea presides over the	first	(month).
Tamatea tu rua	.. ,,	second	,,
Tamatea tu toru	.. ,,	third	,,
Tamatea tu wha	.. ,,	fourth	,,
Tamatea tu rima	. ,,	fifth	,,
Tamatea tu ono	.. ,,	sixth	,,
Tamatea tu whitu	.. ,,	seventh	,,
Tamatea tu waru	.. ,,	eighth	,,
Tamatea tu iwa	.. ,,	ninth	,,
Tamatea tu ngahuru	.. ,,	tenth	,,
Tamatea tu ma-tahi	.. ,,	tenth and one = eleventh (month).	
Tamatea tu ma-maroa	,,	tenth and extended two = twelfth (month).	

That table shows the true use of *ngahuru* as a factor of numeration. I present another table, which treats of the months by numbers only, in a form which answers the question, "What is the number of this month ?"

He tahi .	.. It is a first.	He waru	.. It is an eighth.
He rua .	second.	He iwa ..	.. It is a ninth.
He toru .	third.	He ngahuru ..	,, tenth.
He wha .	fourth.	He ngahuru taitahi	,, tenth and an odd one = eleventh.
He rima .	fifth.		
He ono .	sixth	He ngahuru tairua	,, tenth and two odd ones = twelfth.
He whitu .	seventh.		

The following ritual is based on the ancient myth of the ascent of the divinity Tawhaki to the tenth heaven, and, as the heavens are set out numerically, it is of interest to note the process. Its burden is that

Tawhaki ascended the first heaven, then the second, and so on to the tenth:—

Piki ake Tawhaki i te rangi tuatahi = first heaven.
He rongo te mahaki.
Piki ake Tawhaki i te rangi tuarua = second heaven.
He rongo te mahaki.
Piki ake Tawhaki i te rangi tuatoru = third heaven.
He rongo te mahaki.
Piki ake Tawhaki i te rangi tuawha = fourth heaven.
He rongo te mahaki.
Piki ake Tawhaki i te rangi tuarima = fifth heaven.
He rongo te mahaki.
Piki ake Tawhaki i te rangi tuaono = sixth heaven.
He rongo te mahaki.
Piki ake Tawhaki i te rangi tuawhitu = seventh heaven.
He rongo te mahaki.
Piki ake Tawhaki i te rangi tuawaru = eighth heaven.
He rongo te mahaki.
Piki ake Tawhaki i te rangi tua-iwa = ninth heaven.
He rongo te mahaki.
Piki ake Tawhaki i te rangi tua-ngahuru = tenth heaven.
He rongo te mahaki.

Upon his reaching this tenth (*ngahuru*) heaven, the ritual proceeds to recite his doings there. It is to this Tawhaki that a tithe or tenth portion of food is offered up, and the following reference to the practice occurs in White's "Ancient History of the Maori" (vol. i, p. 40): "*E kore e kiia te kai tuku ki a Tawhaki ki te kupu nei* '*Tekau,*' *engari* '*Ngahuru*'; which is to say, (A tenth portion of) food offered up to Tawhaki is not served in the ordinary term 'Tekau,' but (is served in the term) 'Ngahuru.'" That instruction is definite and very much to the point, which is that the term *ngahuru* has a peculiar mission: to use the ordinary term *tekau* in the place of *ngahuru* is a subversion of that mission.

In the light of that explanation of the history of the term *ngahuru*, and in the light of the examples given, which may be multiplied by genuine reference, I have no hesitation whatever to ask students to accept that, to the Maori, *ngahuru* is not a name for ten.

From those examples, which indicate the peculiarity of the meaning of the term *ngahuru*, a peculiarity which restricts its use—in a method of progressive numeration—to the number twelfth, I pass on to consider the misuse of the term by Mr. Best.

In his examples and tables Mr. Best freely uses the term *ngahuru* as representing ten. For the correctness of this (mis)use he cites no acceptable Maori authority, but he does quote authority: "*Ngahuru.*—This is the old Maori word for ten, now replaced by the term *tekau.* This word [presumably *ngahuru*], recognisable under various letter-changes, is in use over a wide area in the Pacific: Rarotongan, *ngauru* = ten; Hawaiian, *anaulu* = ten days; Samoan, *gafulu* = ten. (See Tregear's Dictionary for many other comparatives)": and so on. So that, failing Maori authority on a subject which he has the assurance to entitle "Maori Numeration," Mr. Best calmly refers the inquirer to those remote sources. Now, while one does not object to Mr. Best going abroad to seek all the information he can, one does object to his introduction of foreign practices (or alleged practices) to show what the Maori really should do; nay, more, what the Maori does, or did. To those who know little or nothing about the matter it is all very well to say, "See Tregear's Dictionary for many other comparatives." Mr. Best might have added, "See also Turner's 'Samoa' for comparatives." Turner gives a list of numerals purporting to be those used by natives speaking fifty-nine different dialects. In that list he, quite wrongly, shows that the Maori uses the term *ngahuru* for ten. So it is with the rest of such compilers, who continue to copy each other without improvement. Whereas we require particularities, they give us generalities. *Ngahuru* is a term which has a known history. If the compilers of such comparatives as Mr. Best refers to have anything to offer in regard to this, let them do so now. In the meantime, let us speak of "Maori Numeration."

I quote Mr. Best: "The late Mr. A. S. Atkinson mentions, in a pamphlet published by him in 1893, that both Archdeacon Maunsell and Bishop Williams—two excellent Maori scholars—agreed in saying that among some tribes *ngahuru* meant ten, and *tekau* eleven: Bishop Williams saying that they counted by elevens, the eleventh being a tally; and he compares our 'baker's dozen.'" I quite agree as to the "two excellent Maori scholars," for those two men did the bulk of translating into Maori the contents of the Old and New Testaments, a monumental work. As to their agreement on the question of *ngahuru* meaning ten, I find no evidence of it in their great work. I deny most emphatically that the Maori seriously used *tekau* to indicate eleven, the "baker's dozen" notwithstanding. Apart from that, I find the following paragraphs in the Maori Dictionary which bears Bishop Williams's name on the title-page:—

> *Ngahuru* (a.), ten.
>
> *Ngahuru* (n.), the name of the eleventh and twelfth months, the eleventh being *ngahuru-kai-paenga* and the twelfth simply *ngahuru*, harvest-time. [Here follows an untranslated Maori reference, which renders, "Let us not go there until the *ngahuru* (*i.e.*, harvest-time); until the food-crops are first safely stored away."]

Those erroneous definitions of the term *ngahuru* constitute one of the few blemishes in a work for which I have little else but praise. Though limited in its extent, in the judicious selection of its references, in the masterful and minute treatment of its examples, as in the faithfulness of its definitions, it has been for very many years, and still is, a most reliable standard work of Maori information.

In the definitions under notice, however, Mr. Williams treats of *ngahuru* as a numeral factor signifying ten, eleventh, twelfth. It is at once obvious that we are given here a set of meanings attached to the single term *ngahuru* which could tend to nothing but confusion. To say that *ngahuru* means ten, that *ngahuru* also means eleventh (for the *kai-paenga*, or food-plenty, cannot help him), and that *ngahuru* also means twelfth, is simply nonsense. No form of Maori speech sets up such a contradictory position. As a matter of fact, *ngahuru* has not the force of ten; *ngahuru* has, as I hope I have sufficiently shown, the force of tenth. *Ngahuru-kai-paenga* literally signifies *ngahuru*-food-plenty, or the food-abundance of harvest-time. It is plain that Mr. Williams does not quite understand the true meaning of *ngahuru*. I say "not quite," because when he speaks of it as a name for either the eleventh or twelfth month he is somewhat near the truth, for it is a name for the tenth month. The paragraphs under notice have already done sufficient mischief, and ought to be expunged from a future edition; for compilers such as Turner would feel quite justified in using terms and meanings which occur in such a commendable work as Williams's Dictionary. A paragraph like the following might be substituted:—

> *Ngahuru* (n.), autumn; harvest-time; a name for the harvest—*i.e.*, tenth month. As an adjective, tenth.

Upon the question of the general use by the islanders of the central Pacific of some form of *ngahuru* for ten I have little to offer. I have made some little progress in the study of several leading dialects, but have found nothing which I would care to adapt to Maori with a view to its improvement. I am not inclined to seek from those sources the first principles of the language, any more than I would expect to find from them particular instructions in matters of Maori art, such as carving and tattooing. While dictionary-makers and compilers generally neglect to define, where ascertainable, the derivation and legitimate uses of words, students will continue to remain very much in the dark as to such. The Hawaiian *anahulu* (= ten days) is something to the purpose, but it is not enough. An Easter Island *angahuru* for ten occurs in our table. But, as I have tried to show, that table exhibits peculiarities which are apparently not entirely due to dialect alone, but rather to compilers and to their assistants. On the other hand, it can be readily proved that the Maori has from time immemorial used the term *mahuru* for spring-time, and that the term speaks of returning warmth and spring growth. It is equally clear that for a similar long period the allied term *ngahuru* has been used to indicate harvest-time, the harvest month—incidentally, the tenth month of the year. What, one may ask, is the original and true meaning of their forms of *ngahuru* to the islanders of the central Pacific? With that question I leave it.

(*c.*) THE TERM "TEKAU."

The question for our consideration is this: Had the Maori an original name for ten? To those who understand something of the past history and language of the Maori the question would appear to be ridiculous. None the less, that is the position which Mr. Best forces upon us; for he urges that *tekau* sometimes meant ten, that it sometimes meant eleven, and that it sometimes meant twenty. So that *tekau* apparently had no fixed meaning. He states this: "I cannot prove that among all the Maori tribes of New Zealand *tekau* represented twenty"; and so on. Of course Mr. Best cannot prove it; but why should he try? Again, he states, "As old Tutaka expressed it, '*Tekau* as a term for ten is a modern usage. It was the white man and his books that made it known to us.'" "The white man and his books!" Save us from such authorities as we have here!

Mr. Best proceeds, "Several old Natives of the Tuhoe and Ngatiawa Tribes confirm the statement that *tekau* was formerly used to denote twenty, and was not used for ten. As *kau* seems to have been a Polynesian word meaning 'collection' or 'assembly,' then the expression would probably have been originally *te kau* = the whole, or the assembling of the ten fingers and ten toes." "Ten fingers and ten toes!" This is put forward as a suggestion that ten did not really mean ten of the fingers, but twenty—the ten fingers and ten toes together—a suggestion without authority. Presumably it is from the same old Native that Mr. Best obtains his names for the "five fire-children," whose names, according to Mr. Best, are "*takonui* (thumb), *takoroa* (forefinger), *manawa, mapere, toiti*. These are termed the *tokorima a Maui* (the five of Maui)." The "five of Maui" is an euphemism for the five fingers of man, which produce the sacred fire by means of friction. Now, the name of the thumb is *koromatua*; that of the fingers *matikao, matikara*. When a Native wishes to enumerate them in their regular order he uses the numeral prefix *toi* (the *tako* of Mr. Best), in this way: *Toi-nui* (great finger, thumb); *toi-roa* (extended, index finger); *toi-*

mapere (centre finger); *toi-manawa* (pulsation, heart finger); and *toi-iti* (little finger), the *toiti* of Mr. Best. There is, you will observe, quite a presentable likeness between this set of terms and that given by Mr. Best. The one particular difference is that, whereas Mr. Best gives *manawa* as the term for the middle finger and *mapere* for the next, I show that the reverse is the case, the simple reason for this being that the *toi-manawa* is literally the heart finger, from *manawa*, heart. It is an instance of the Maori meaning exactly what he says; he does not (neither logically could he) call the middle finger the *manawa*, or heart finger. We have very clear evidence here that those from whom Mr. Best draws his information are—well, very careless in matters of nice knowledge.

Mr. Best goes on: "*Tekau.*—This term, as already observed, is now applied to ten, but the old men of the Tuhoe Tribe agree that in pre-European days it was applied to twenty only, never to ten." Here we have one of many similarly rash statements. It strongly implies that the European has left his mark on the system of Maori numeration. It is scarcely necessary to deny that that is so. There is absolutely not a single trace of European innovation in any of the many different modes of Maori numeration — not a single trace. As to pre-European days, a favourite finger-game of the Maori, *karihi-taka*, undoubtedly belongs to pre-European days; it is, so to speak, as old as the hills. It is a game of ten points, and this is how the points were enumerated:—

Karihi-taka tahi	One.	Karihi-taka ono	Six.
Karihi-taka rua	Two.	Karihi-taka whitu	Seven.
Karihi-taka toru	Three.	Karihi-taka waru	Eight.
Karihi-taka wha	Four.	Karihi-taka iwa..	Nine.
Karihi-taka rima	Five.	Karihi-taka kau	Ten. (Game.)

(NOTE.—The *te* of *tekau* is omitted, as its use would mar the otherwise perfect rhythm.)

Again as to pre-European days, it will not, I think, be denied that the earlier Maori recitals, legends, &c., published in Grey's "Polynesian Mythology" and White's "Ancient History of the Maori," bear internal evidences of genuine antiquity. In one of these recitals—that relating to the wanderings of the divinity Tawhaki and his mortal brother Karihi—you will find the following recorded: "This old lady was at the moment employed in counting some taro-roots which she was about to have cooked, and, as she was blind, she was not aware of the strangers who stole quietly and silently up to her. There were ten taro-roots lying in a heap before her. She began to count them—One, two, three, four, five, six, seven, eight, nine. Just at this moment Tawhaki quietly slipped away the tenth. The old lady felt about everywhere for the tenth, but she could not find it. She thought she must have made some mistake, and so began to count her taro-roots over again very carefully—One, two, three, four, five, six, seven, eight. Just then Tawhaki had slipped away the ninth"; and so on. (Grey's "Mythology": English version, pp. 42–3; Maori version, p. 51.) This counting incident is a very essential and characteristic feature of the recital, and there we find the old lady using the *ka* prefix in counting, and the *tekau*, or ten, is used no less than three times. Grey, in his translation, uses the equivalent twice only; I have taken the liberty to insert it a third time in the extract, so that it corresponds exactly with the Maori version. How old the Tawhaki-Karihi legend is it is now useless to inquire, but its roots are deeply struck throughout the central Pacific. In the "Journal of the Polynesian Society," vol. vii, p. 40, there occurs the best table of

Maori genealogical descent from Karihi, the human brother of Tawhaki, that I know of. That table shows fifty-two generations from Karihi to living descendants. That represents some 1,456 years.* The point is that we have here very first-class evidence of the ancient usage of *tekau* for ten, a usage which Mr. Best has the assurance to deny.

It may be stated as an indisputable fact that by the original usage of *tekau* for ten the Maori has built up—and slowly—the comprehensive system of numeration of which examples are particularly given in our Tables A, B, C, D, and E. It may also be plainly stated that but for that usage of *tekau* for ten we should not now have had those tables to contemplate. Mr. Best and his authorities must alike fail in any attempts to set up a standard other than ten as an equivalent for *tekau*. Even in Williams's Dictionary the legend occurs, "*Tekau* (a.), ten"; nothing more. The early translators of the Prayer-book and of the New and Old Testaments regularly use *tekau* for ten and tenth; and they have not done this as a mere innovation, but because the Maori so understood it.

CONCLUSION.

During the course of this essay I undertook to incidentally show that Mr. Best's observations on (*a*) the numeral prefix are entirely inadequate, and that those upon (*b*) the term *ngahuru* and (*c*) the term *tekau* require considerable modification.

I submit that I have now sufficiently done so, and, further, that I have shown his authorities to be unreliable in the very matters upon which Mr. Best apparently depended for his proofs.

I now conclude by expressing my belief that the authorities and sources to which I myself have referred the subject will be found to be absolutely reliable. And there I now leave it.

---

* By a printer's error the son of Karihi—namely, Rutapatapaiawha—has been omitted from the table, which is thus a generation short. The generation-measuring rod which I use I have made from materials supplied by Burke's "Peerage." That work shows that William the Conqueror was born A.D. 1025, and his descendant the present Prince of Wales in the year 1865. Between these dates there is a space of 840 years, representing thirty generations from King to Prince. Thirty multiplied by twenty-eight gives us 840, and thus an authentic measuring-rod of twenty-eight years to each generation. There are fifty-two generations from our Karihi, the human brother of Tawhaki, to his living descendants of the year 1865. Measured by our standard rod of twenty-eight years to a generation, we get 1,456 years, or A.D. 453, as the period of Tawhaki and Karihi. I make no apology for using this measuring-rod of my own invention, because—(*a*) we want facts, and we are very close to them here; and (*b*) we are utterly without the means to make an adequate measuring-rod of purely Native material. We cannot get back a sufficient distance in time to a date from which to strike a fair average. No local standard can be fixed on grounds other than pure guesswork

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